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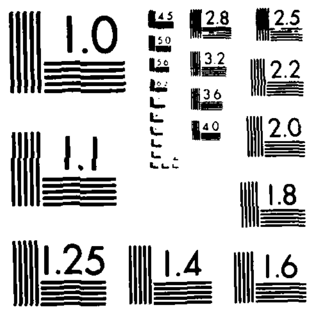
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US Army Corps
of Engineers
New Orleans District

AD-A152 724

Mississippi and Louisiana Estuarine Areas

Freshwater Diversion to Lake Pontchartrain Basin and Mississippi Sound

Feasibility Study

Volume 2
Technical Appendixes
A, B, C, D
April 1984

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ESTUARIES	SALTWATER INTRUSION	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The study area has experienced land loss and saltwater intrusion due to natural processes such as subsidence and erosion, as well as man's developmental activities including leveeing, channelization, and petroleum exploration. The various natural processes and man's activities have altered overbank flooding and natural distributary flow which historically provided fresh water, sediments, and nutrients to the estuarine areas. This has resulted in conversion of fresh, intermediate, and brackish marshes to more saline marsh types and has

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20. ABSTRACT (CONTINUED)

also caused the loss of substantial areas of wooded swamp. Saltwater intrusion and loss of wetlands have adversely affected the productivity of wildlife and fishery resources. Influx of saline waters is particularly harmful to the American oyster, due to increased predation and disease. Thousands of acres of formerly productive oyster reefs in the area lie largely unproductive due to excessive salinities. One way to ameliorate loss of wetland habitat and rate of saltwater intrusion is timely introduction of fresh water and associated sediments and nutrients into the study area. A total of 13 potential sites were evaluated for diversion of fresh water. Based on the results of this study, it has been recommended that fresh water from the Mississippi River be diverted into Lake Pontchartrain at a site adjacent to the Bonnet Carre' Spillway. This site is located at river mile 128.5. Implementation of this plan would save approximately 4,186 acres of marsh and 6,355 acres of wooded swamp. Additionally, average annual oyster production in the study area would increase by about 7.5 million pounds.

APPENDIX A

BACKGROUND INFORMATION AND PROBLEM IDENTIFICATION

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF PLATES

MISSISSIPPI AND LOUISIANA ESTUARINE AREAS STUDY

Report on Freshwater Diversion

Lake Pontchartrain Basin and Mississippi

Appendix A

PROBLEM IDENTIFICATION

A.0.1. The Problem Identification Appendix defines the authority for the Mississippi and Louisiana Estuarine Areas study. Prior studies and reports of the US Army Corps of Engineers and others that encompass the study area or portions of the area are cited. Existing conditions of the land, water, biological, cultural, recreational, and human resources are portrayed. The demography, economy, and land use of the area are described. Area resources and economy are projected into the future to determine conditions if no Federal action is taken. Water and related land resources problems, needs, and opportunities are identified and planning objectives are developed for the study. Planning constraints affecting the study are established.

Section 1. STUDY AUTHORITY AND SCOPE

A.1.1. The Mississippi and Louisiana Estuarine Areas study was conducted in response to a resolution of the Committee on Public Works and Transportation of the United States House of Representatives. The resolution was sponsored by Congressman Trent Lott, Fifth Congressional District of Mississippi, and was adopted on 23 September 1976. The authorizing Resolution reads:

> "Resolved by the Committee on Public Works and Transportation of the House of Representatives, United States, that the Chief of Engineers of the US Army is hereby requested to review the report on the Mississippi River and Tributaries, published as House Document 308, 88th Congress, and other pertinent reports with a view to determining the advisability of modifying the recommendations contained therein with particular reference to providing fresh water into Lakes Maurepas, Pontchartrain, Borgne, and Mississippi Sound areas in the interest of improving the wildlife and fisheries of this area."

A.1.2. Although the resolution specifically states that freshwater diversion should be investigated as a measure for improving fish and wildlife productivity, other measures were also identified and evaluated to determine their effectiveness. Related water resources problems, needs, and opportunities were analyzed including those of sport fishing and hunting, commercial fishing and trapping, outdoor recreation, water quality, cultural resources, and preserving environmentally unique and sensitive areas.

A.1.3. The study area covers 2,960,000 acres. In Louisiana, it encompasses the Lower Mississippi River, Lakes Maurepas, Pontchartrain, Catherine, and Borgne, and the marshes bordering these lakes. In southern Mississippi, the study area embraces the Mississippi Sound and surrounding wetlands. The east bank of the Mississippi River between

Bayous Manchac and the Mississippi River-Gulf Outlet (MR-GO) is included in the area. Plate A-1 is a map of the study area.

Section 2. PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS

A.2.1. The US Army Corps of Engineers, other Federal and state agencies, and individuals have prepared numerous studies and reports concerning water resources development in the area. However, only the reports and projects pertinent to the present study are described here.

A.2.2. Construction of the Bonnet Carre' Spillway was authorized by the Flood Control Act of 15 May 1928 and amendments. The purpose of the project is to provide protection for the city of New Orleans. The spillway is used to prevent the river stage at the Carrollton gage in New Orleans from exceeding 20 feet National Geodetic Vertical Datum (NGVD). Although the spillway was constructed for flood control purposes, spillway openings have been beneficial overall and have resulted in increased fish and wildlife productivity in subsequent years. The spillway was opened in 1937, 1945, 1950, 1973, 1975, 1979, and 1983.

A.2.3. No freshwater diversion projects have been constructed in the study area. However, adjacent to the study area along the lower Mississippi River in Plaquemines Parish, the State of Louisiana and local interests have constructed five freshwater diversion structures: Bayou Lamoque No. 1, Little Coquille, Bohemia, Bayou Lamoque No. 2, and White's Ditch (plate A-2).

- Bayou Lamoque No. 1. In 1955, the Louisiana Department of Public Works constructed a freshwater diversion structure on the east bank of the Mississippi River at Bayou Lamoque in the Pointe-a-la-Hache Relief Outlet. This structure consists of four 10- by 10-foot gated conduits that divert fresh water from the river through an improved Bayou Lamoque to reduce salinity concentrations on the oyster beds in the bays east of the river.

TABLE A-3-2

PER CAPITA PERSONAL INCOME, 1950 - 1980

	1950	1959	1969	1980
Mississippi	755	1,222	2,402	6,580
Biloxi-Gulfport SMSA 1/	1,351	1,591	2,958	6,903
Hancock County	1/	1,271	2,519	5,475
Harrison County	1/	1,651	3,066	7,131
Pascagoula-Moss Point SMSA				
Co-extensive with Jackson County	1,096	2,033	2,823	6,911
Mississippi Portion of the Study Area	-	1,730	2,900	6,910
Louisiana	1,120	,1,670	2,895	8,458
Baton Rouge SMSA 1/	1,294	1,982	3,180	9,435
Ascension Parish	1/	1,613	2,328	7,559
Livingston Parish	1/	1,138	2,399	7,360
New Orleans SMSA	1,523	2,111	3,500	9,791
Jefferson Parish	1/	2,238	3,629	10,057
Orleans Parish	1/	2,110	3,513	9,911
St. Bernard Parish	1/	1,902	3,418	9,523
St. Tammany Parish	1/	1,601	2,740	8,247
Non-SMSA Parishes				
St. Charles Parish	1,067	1,887	2,724	8,844
St. James Parish	686	1,391	2,533	8,683
St. John the Baptist Parish	721	1,466	2,190	7,881
Tangipahoa Parish	751	1,176	2,110	6,302
Louisiana Portion of the Study Area	-	1,990	3,300	9,340
Total Study Area 2/	-	1,960	3,240	8,940
United States	1,493	2,201	3,945	9,521
In Constant 1972 Dollars	-	3,069	4,265	5,322

Sources: U.S. Dept. of Commerce Bureau of Economic Analysis, "Survey of Current Business". U.S. Dept. of Commerce Bureau of the Census, Statistical Abstract of the United States.

1/ Figures for 1950 include the entire Standard Metropolitan Statistical Area (SMSA).

2/ The Total Study Area includes only the 10 parishes and three counties, and not SMSA's.

population is concentrated in the New Orleans Standard Metropolitan Statistical Area (SMSA), which includes Orleans, Jefferson, St. Bernard, and St. Tammany Parishes. These parishes contain 1,187,073 people, about 67 percent of the population of the study area. The population in Mississippi is concentrated in the Biloxi-Gulfport SMSA. About 11 percent of the study area population resides here. The Biloxi-Gulfport SMSA includes Stone County which is north of the Mississippi coastal counties and is not part of the study area. Other areas of population concentration are along the east bank of the Mississippi River west of New Orleans, along the Mississippi Gulf Coast, and in the southern portion of Tangipahoa Parish. The study area is 84 percent urban and 16 percent rural.

PER CAPITA INCOME

A.3.3. The 1980 per capita personal income averaged $8,940 for the study area compared with the combined state and national averages of $7,754 and $9,521, respectively.

A.3.4. Of the 10 parishes and three counties in the study area, five parishes and two counties had per capita personal incomes above the state averages ($8,458 in Louisiana, $6,580 in Mississippi). They were Jefferson, Orleans, St. Bernard, St. Charles, and St. James Parishes and Harrison and Jackson Counties. The per capita personal income for Louisiana was 98 percent of the national average as compared to 73 percent for Mississippi in 1980. From 1970 to 1980, the real per capita personal income increased in all parishes. Per capita personal income by parish and county for 1950 to 1980 is shown in table A-3-2.

TABLE A-3-1

COMPARATIVE POPULATION TRENDS, 1950 TO 1980

	1950	% Change	1960	% Change	1970	% Change	1980
Mississippi	2,178,914	-	2,178,914	1.02	2,216,994	1.14	2,520,638
Biloxi-Gulfport SMSA 1/	102,228	1.37	140.541	1.14	160,070	1.20	191,918
Hancock County	11,891	1.18	14,039	1.24	17,387	1.41	24,537
Harrison County	84,073	1.42	119,489	1.13	134,582	1.17	157,665
Pascagoula-Moss Point SMSA 1/ (coextensive with Jackson County)	31,401	1.77	55,522	1.58	87,975	1.34	118,015
Mississippi Portion of the study area	127,365	1.48	189,050	1.27	239,949	1.25	300,217
Louisiana	2,683,516	1.21	3,257,022	1.12	3,644,637	1.15	4,205,900
Baton Rouge SMSA 1/	212,415	1.41	299,755	1.25	375,628	1.26	444,151
Ascension Parish	22,387	1.25	27,927	1.33	37,086	1.35	50,068
Livingston Parish	20,054	1.35	26,974	1.35	36,511	1.61	58,806
New Orleans SMSA	712,393	1.27	907,123	1.15	1,046,470	1.13	1,187,073
Jefferson Parish	103,873	2.01	208,769	1.62	338,229	1.34	454,592
Orleans Parish	570,445	1.10	627,525	-	593,471	-	557,515
St. Bernard Parish	11,087	2.90	32,186	1.59	51,185	1.25	64,097
St. Tammany Parish	26,988	1.43	38,643	1.65	63,585	1.74	110,869
Non-SMSA Parishes							
St. Charles Parish	13,363	1.59	21,219	1.39	29,550	1.26	37,259
St. James Parish	15,334	1.20	18,369	1.07	19,733	1.09	21,495
St. John the Baptist Parish	14,861	1.24	18,439	1.29	23,813	1.34	31,924
Tangipahoa Parish	53,218	1.12	59,434	1.11	65,875	1.23	80,698
Louisiana Portion of the Study area	851,610	1.27	1,079,485	1.17	1,259,038	1.17	1,467,323
Total Study Area 2/	978,975	1.30	1,268,535	1.18	1,498,982	1.18	1,767,540
U.S. (1,000's)	151,326	1.19	179,323	1.13	203,302	1.11	226,505

Source: US Department of Commerce, Bureau of the Census, 1980 Census of Population, "Number of Inhabitants".

1/ SMSA - Standard Metropolitan Statistical Area - The Biloxi-Gulfport SMSA includes Stone County; the Baton Rouge SMSA also includes East and West Baton Rouge Parishes.

2/ The Total Study Area includes only the ten parishes and three counties, not the SMSA's.

Section 3. EXISTING CONDITIONS

HUMAN RESOURCES AND ECONOMY

A.3.1. The 10 parishes and three counties partially included in the study area are Ascension, Jefferson, Livingston, Orleans, St. Bernard, St. Charles, St. James, St. John the Baptist, St. Tammany, and Tangipahoa Parishes, and Hancock, Harrison, and Jackson Counties. (Plate A-11) In compiling statistical data for the Human Resources and Economy section, all of the 10 parishes and three counties located partially in the study area were included because they are economically significant to the study area. It would be virtually impossible to accurately disaggregate the statistical data according to the study area boundaries. Although many residents of the parishes and counties do not live in the study area, they work and play there and contribute extensively to the economy of the area. These people heavily utilize area resources for hunting, fishing, and general outdoor recreation. The study area in this section refers to the economic study area that entirely encompasses the 10 parishes and three counties.

POPULATION CHARACTERISTICS

A.3.2. Population of the study area in 1980 (table A-3-1) was approximately 1,800,000, an increase from 1970 levels of 1,500,000 or 17 percent. The annual growth rate of 0.55 percent during this period exceeded both the national growth rate of 0.35 percent and the combined state rate of 0.46 percent. Overall, the study area population grew faster than the total population of Louisiana and Mississippi. Orleans Parish experienced a slight out-migration of 6 percent; while all other parishes and counties gained in population. The largest in-migrations were in St. Tammany Parish (74 percent), Livingston Parish (61 percent), and Hancock County (41 percent). In Louisiana, the study area

proposed navigation improvements in the Mississippi Sound and Mobile Bay and determine possible changes in these practices to enhance environmental quality and create a regional dredging program. The study will also collect salinity, sediment, and tide data and with the aid of a mathematical model will determine the water circulation and salinity patterns in the area. This data will be used in the present study where appropriate. A reconnaissance report was published in March 1979 and the final feasibility report is scheduled for completion in July 1984.

Report No. 16	Hydrologic Models for the Barataria-Terrebonne Area, South Central Louisiana
Report No. 17	The Shell Dredging Industry; Its Impact on Louisiana
Report No. 18-1	Multi-Use Management Plan for South Central Louisiana
Report No. 18-2	Environmental Atlas

A.2.19. The Louisiana Coastal Area study was authorized by resolution of the Committees on Public Works of the United States Senate and the House of Representatives and adopted on 19 April 1967 and 19 October 1967, respectively. Under the study, the New Orleans District is investigating improvements in hurricane protection, prevention of saltwater intrusion, preservation of fish and wildlife, prevention of erosion, and related water resources problems in coastal Louisiana. A number of broad studies concerning the entire coastal area were conducted. A revised draft interim report on freshwater diversion to Barataria and Breton Sound Basins is being prepared and will be submitted to higher authority in 1984. The report will recommend constructing a freshwater diversion structure into Breton Sound Basin near Caernarvon and into Barataria Basin near Davis Pond. The final report on the overall study is scheduled for completion in 1987.

A.2.20. The Mississippi Sound and Adjacent Areas (MSAA) study was authorized by a resolution of the Committee on Environment and Public Works of the United States Senate, adopted 1 February 1977, and the Committee on Public Works and Transportation of the United States House of Representatives, adopted 10 May 1977. The MSAA study is being conducted by the US Army Engineers, Mobile District. This study will assess dredging and dredged material disposal practices in existing and

are:

Report No. 1	Geologic and Geomorphic Aspects of Deltaic Processes, Mississippi Delta System
Report No. 2	Salinity Regimes in Louisiana Estuaries
Report No. 3	Water Balance in Louisiana Estuaries
Report No. 4	Summary of Salinity Statistics, Coastal Louisiana Stations, 1964-1968
Report No. 5	Salinity and Temperature Atlas of Louisiana Estuaries
Report No. 6	Seasonal Precipitation Surplus and Annual Precipitation Deficit Maps of South Louisiana, 1945-1968
Report No. 7	Louisiana Wildlife and Fisheries Water Chemistry Survey Data, Louisiana Estuaries, 1968-1969
Report No. 8	Controlled Diversions in the Mississippi Delta System: An Approach to Environmental Management
Report No. 8-S	Hydrologic and Meterologic Data from Coastal Louisiana Evaluation of Data Gaps
Report No. 9	Deterioration and Restoration of Coastal Wetlands
Report No. 10	Selected Environmental Parameters, Coastal Louisiana, 1945-1946, 1959-1965
Report No. 11	Statistical Model for Salinity Distributions, Southeastern Louisiana Estuaries
Report No. 12	Wave Energy Studies Along the Louisiana Coast
Report No. 13	Development of the Atchafalya Delta, Louisiana
Report No. 14	Canals, Dredging, and Land Reclamation in the Louisiana Coastal Zone
Report No. 15	Measurement of Louisiana Coastal Shoreline

diversion sites, establishes a study cost and time frame for completing a freshwater diversion plan for the state, and describes mechanisms for implementing the plan. The plan includes the freshwater diversion sites in the Mississipi Delta Region project and the sites currently being investigated under the present study. In October 1981, the Louisiana Senate and House Committees on Natural Resources issued a "Report on Special Projects for Coastal Louisiana." The report identifies and discusses the particular problems of land loss, coastal erosion, wetlands deterioration, and saltwater intrusion as well as the potential solutions readily available to fight the processes adversely affecting coastal Louisiana. Specific projects are suggested in the discussion of solutions. The committees directed the administrator of the Coastal Management Section, Louisiana Department of Natural Resources, to recommend projects to control coastal erosion and wetlands loss. The administrator to the Department of Natural Resources recommended a series of pilot projects for beach erosion and marsh building and specified that the Caernarvon freshwater diversion project be given top priority. Because the Caernarvon site was included in the authorized Corps of Engineers Mississippi Delta Region project, the Governor of Louisiana provided a letter of intent to the Corps on 26 January 1982 for the Caernarvon structure.

A.2.18. The Center for Wetland Resources, Louisiana State University, was retained under contract by the Corps of Engineers to perform a number of basic studies of the hydrologic and geologic characteristics of coastal Louisiana. The studies examined and identified trends in the coastal area resulting from natural processes and human activities, identified significant environmental parameters, determined freshwater requirements for fish and wildlife enhancement, and developed management and structural approaches to solving problems in the estuarine environment. The findings and recommendations are contained in a series of 18 reports. The last report was published in late 1973. The 18 reports

wildlife study resulted in the following products: a vegetative type map depicting conditions in the coastal marshes during August 1968, a soil and vegetative type analysis, a game inventory to determine habitat preference of important commercial and sport wildlife species, analyses of estuarine ecology resources and resource development needs to establish the relationship between commercial fish production and environmental characteristics of the estuarine ecosystem, and the sport fishing, hunting, and wildlife-oriented recreational activity and demand in coastal Louisiana. Pertinent data was incorporated where appropriate.

A.2.16. The New Orleans-Baton Rouge Metropolitan Area (NOBRMA), Louisiana, Water Resources study was authorized by a resolution of the Committee on Public Works of the United States House of Representatives, adopted 14 June 1972. In the study conducted by the New Orleans District, the Lake Pontchartrain and Vicinity report, Amite River and Tributaries, Louisiana, report, and other pertinent reports were reviewed to determine whether any of the recommendations could be modified. Modified recommendations could be incorporated into a plan for development, use, and conservation of water and related land resources in the New Orleans-Baton Rouge metropolitan region. The study was completed in 1981. The Louisiana portion of the Mississippi and Louisiana Estuarine Areas study was included in the NOBRMA study. Data from the NOBRMA study has been incorporated where appropriate.

A.2.17. The Louisiana Department of Transportation and Development (LDOTD) prepared a plan of study (POS) dated April 1980 to investigate diverting fresh water and sediment to improve the coastal marshes, estuaries, and barrier islands of Louisiana. The POS, which is in response to the Louisiana Legislative Act 561 of 1978, summarizes existing information on marsh loss, saltwater encroachment, and barrier island deterioration, identifies possible freshwater and sediment

just north of the Bonnet Carre' Spillway and that fresh water be diverted into the Breton Sound Basin just south of Caernarvon via Big Mar. The report was also intended to supplement parallel studies by the US Army Corps of Engineers as part of the Louisiana Coastal Area and the Mississippi and Louisiana Estuarine Areas studies.

A.2.14. A review of the Mississippi River and Tributaries project, prepared by the New Orleans District and printed as House Document No. 308, 99th Congress, 1st Session, recommended the construction of four salinity control structures to introduce fresh water into the marshes of the Mississippi Delta Region. The structures are Myrtle Grove, Homeplace, Bohemia, and Caernarvon. The project was authorized by the Flood Control Act of 1965. Advanced engineering and design on the Bohemia structure was initiated in 1969. However, work was suspended at the request of local interests. The four sites were reevaluated in the draft Louisiana Coastal Area study, March 1982, and the Caernarvon site was recommended for construction. Advanced engineering and design on the Caernarvon site has been initiated.

A.2.15. A fish and wildlife study of the Louisiana Coastal area and Atchafalaya Basin Floodway was conducted by the New Orleans District in support of the Louisiana Coastal Area study, West Texas and Eastern New Mexico Water Import study (Mississippi River Commission, 1973), Lower Mississippi Region Comprehensive study (Lower Mississippi Region Comprehensive study, Coordinating Committee, 1974), Atchafalaya Basin Water and Land Resources study (US Army Corps of Engineers), and the National Shoreline study (US Army Corps of Engineers, 1971). The fish and wildlife study includes a preliminary determination of the cyclic quantities of supplemental fresh water needed to optimize productivity of fish and wildlife resources and possible options for supplying this water to Lakes Maurepas, Pontchartrain, and Borgne. Special studies and investigations undertaken to obtain essential inputs for the fish and

A.2.10. The US Fish and Wildlife Service (USFWS) developed an ecological characterization of the Mississippi Deltaic Plain Region for a report entitled, "Mississippi Deltaic Plain Region Ecological Characterization." Published in 1980, the report supplies existing information about the biological, physical, and social parameters of the Mississippi Deltaic Plain Region of Louisiana and Mississippi. Portions of the USFWS report were used in this study.

A.2.11. St. Bernard Parish has conducted studies of its wetlands and established guidelines and goals for a parish wetlands management program. A report defining the wetlands management program was completed in August 1978. Included in the report is a preliminary examination of structural and nonstructural means to implement the program. A draft environmental assessment for the program was completed in April 1979. One feature of the program, the Violet Canal Siphon project, was constructed with funds provided by the Federal Coastal Energy Impact Program. The siphon introduces water into the marshes between the back protection levee and the MR-GO dredged material disposal area. Data accumulated during the monitoring of the siphon will be used in evaluating the effects of freshwater diversion in the marsh area.

A.2.12. St. Bernard Parish completed a Draft Coastal Management Program Document in May 1982. The document will be the basis for parish planners to manage the parish coastal resources. The document is currently being revised based on comments received by the state.

A.2.13. The Louisiana Department of Natural Resources contracted with Coastal Environments, Inc., to provide recommendations for freshwater diversion to Louisiana estuaries east of the Mississippi River. The final report was completed in June 1982. It recommended that fresh water be diverted into the Lake Pontchartrain Basin at a diversion site

A.2.7. The project, "Gulf Intracoastal Waterway Between Apalachee Bay, Florida, and the Mexican Border," authorized by the River and Harbor Act of 1962 and numerous prior river and harbor acts, provides the following improvements within the study area: a 16- by 150-foot channel between the Mississippi and Atchafalaya Rivers via a lock through the west Mississippi River levee at mile 98 above Head of Passes (AHP) in Harvey, Louisiana, an alternate 16- by 150-foot channel connecting the above channel and the Mississippi River via a lock through the west Mississippi River levee at mile 88 AHP in Algiers, Louisiana, a 12- by 125-foot channel connecting the Gulf Intracoastal Waterway at Morgan City, Louisiana, and the Mississippi River at Port Allen, Louisiana, via a lock through the levee at Mississippi River mile 228 AHP, a 12- by 150-foot channel through the Rigolets (between Lakes Borgne and Pontchartrain) and the Mississippi River via a portion of the IHNC and the lock at mile 93 AHP, and annual payments to the Board of Commissioners of the Port of New Orleans for use of a portion of the IHNC and for use of the lock. The 16- by 150-foot channel has not been constructed.

A.2.8. A report entitled "Lake Pontchartrain and Vicinity, Louisiana," published as House Document No. 231, 89th Congress, 1st Session, recommended the construction of hurricane protection levees and barriers at the entrances to the lake to reduce hurricane tides. The project was authorized by the Flood Control Act of 1965. Construction was initiated in 1967, but construction of the barriers was halted in 1978 by court injunction until a new environmental impact statement could be prepared. Construction is continuing on other portions of the project.

A.2.9. The report, "Deep Draft Access for the Port of New Orleans and Baton Rouge, Louisiana," published in July 1981, recommended deepening the Mississippi River between Baton Rouge and the Gulf of Mexico to a 55-foot navigable depth. The report is currently under review at the Office of the Secretary of the Army.

from there to Baton Rouge, Louisiana. All channel work has been completed. Remaining work consists of bank nourishment and jetty work at Southwest Pass and Head of Pass areas.

A.2.5. The report, "Mouth of the Mississippi River, Louisiana," published as House Document No. 215, 76th Congress, recommended combining the existing deep-draft projects on the river under a single project, "Mississippi River, Baton Rouge to the Gulf of Mexico, Louisiana," with modifications to provide the following channel dimensions:

Mississippi River:

Baton Rouge to New Orleans: 35 by 500 feet
Port of New Orleans: 35 by 1,500 feet
New Orleans to Head of Passes: 40 by 1,000 feet
Southwest Pass: 40 by 800 feet
Southwest Pass Bar Channel: 40 by 600 feet
South Pass: 30 by 450 feet
South Pass Bar Channel: 30 by 600 feet

All work was completed.

A.2.6. The report, "Mississippi River-Gulf Outlet," published as House Document No. 245, 82nd Congress, resulted in the authorization of a project under the River and Harbor Act of 1956 that provided a 36- by 500-foot ship channel between the Inner Harbor Navigation Canal (IHNC) in New Orleans and the Gulf of Mexico, Louisiana, a 1,000- by 2,000- by 36-foot turning basin at its junction with the IHNC, and a new high level bridge over the channel at Louisiana Highway 47. Construction was initiated in 1958, and dredging of the channel was essentially completed in 1965. The authorization provides for a lock and connecting channel between the Mississippi River and the new ship channel when economically justified by obsolescence of the existing IHNC lock or by increased traffic. All work has been completed except the lock, connecting channel, jetty construction at Breton Sound, and foreshore protection work.

- Little Coquille. Plaquemines Parish constructed a freshwater diversion structure on the east bank of the Mississippi River at Little Coquille. This structure, used for diverting freshwater to bays east of the river, consists of five 48-inch concrete culverts with provisions to regulate flow.

- Bohemia. In 1970, the Louisiana Department of Public Works completed construction of a freshwater diversion structure on the east bank of the Mississippi River at Bohemia. This structure consists of four 60-inch gated conduits and is used for diverting freshwater to bays east of the river.

- Bayou Lamoque No. 2. In 1977, the Louisiana Department of Public Works completed construction of a second freshwater diversion structure on the east bank of the Mississippi River at Bayou Lamoque just downstream of the existing structure. This structure consists of four 12- by 12-foot gated outlets. The Bayou Lamoque No. 2 structure has helped to double the diversion capacity at Bayou Lamoque. Both Bayou Lamoque structures are operating to meet the needs of the oyster industry in Breton Sound (Coastal Environments, Inc., 1982).

- White's Ditch. A diversion structure was completed at White's Ditch in 1956. The purpose of the structure was to provide freshwater to the River Aux Chenes area. The diversion of fresh water has restored the area to fresh marsh suitable for ducks and furbearers.

A.2.4. The report, "Mississippi River, Baton Rouge to the Gulf of Mexico, Louisiana," published as Senate Document No. 36, 87th Congress, resulted in authorization, under the River and Harbor Act of 1962, to modify the existing project and provide a 40- by 500-foot channel in the Mississippi River from the lower limits of the Port of New Orleans adjacent to the existing 35- by 1,500-foot channel through the port and

EMPLOYMENT

A.3.5. The 1970 Census reported civilian employment (of persons 16 years of age and older) in the study area at 502,000. Of this total, about 368,000 or 73 percent were living in the New Orleans SMSA. In 1980, civilian employment in the study area was estimated at 865,000, a 75 percent increase. Provisional reports of the 1980 Census estimate total employment in the New Orleans SMSA at 489,000, an increase of 33 percent over 1970. Census figures indicate that civilian employment in the State of Louisiana increased from 1,158,000 in 1970 to 1,645,000 in 1980, or 43 percent. Civilian employment in Mississippi increased from 717,000 to 947,000, or about 32 percent.

A.3.6. Table A-3-3 illustrates nonagricultural employment distribution in the study area in 1980. The total area reflected in the table includes entire SMSA's, which encompasses more than the 13 parishes and counties of the economic study area. Sources for Louisiana and Mississippi data in this table differ and do not cover all employment. Agricultural, forestry, and military employment are not included in the table. These figures provide only an indication of the employment distribution in the study area.

A.3.7. The most significant employment categories along the Mississippi Gulf Coast are manufacturing, primarily in the Pascagoula-Moss Point area; and government, retail and wholesale trade, and services in the Biloxi-Gulfport area. Manufacturing accounted for about 45 percent of the non-agricultural employment salaries and wages reported for the Pascagoula-Moss Point area in 1980. The 19,041 manufacturing employment figure of the Pascagoula-Moss Point SMSA (Jackson County) represents a decline from a 1977 employment average of 31,189. This decline appears to be due to layoffs in the manufacture of transportation equipment. For example, employment levels at Ingalls Shipbuilding, Division of

TABLE A-3-3

CIVILIAN NON-AGRICULTURAL WAGE AND SALARY EMPLOYMENT DISTRIBUTION, 1980

	Total[1]	Mining	Construction	Manufacturing	Utilities	Retail & Wholesale Trade	Finance	Services	Government
Mississippi	868,710	10,697	43,494	221,568	41,182	164,015	33,633	161,0[illegible]	187,0[illegible]
Employment Distribution (%)	2/	1.2	5.0	25.5	4.7	18.9	3.9	18.5	21.5
Biloxi-Gulfport SMSA[3]	63,692	32	2,713	8,486	4,079	14,241	2,818	13,248	17,370
Pascagoula-Moss Point SMSA	42,075	80	1,997	19,041	1,205	6,788	1,175	4,572	7,098
Total	105,767	112	4,710	27,527	5,284	21,029	3,993	17,820	24,468
Employment Distribution (%)	2/	0.1	4.5	26.0	5.0	19.9	3.8	16.8	23.1
Louisiana	1,578,900	89,400	138,600	214,200	134,000	359,300	75,000	274,700	300,800
Employment Distribution (%)	2/	5.7	8.8	13.6	8.5	22.8	4.8	17.4	19.1
Baton Rouge SMSA[3]	190,600	800	20,300	26,000	10,200	44,800	11,000	30,500	47,000
New Orleans SMSA	495,200	16,400	30,100	53,700	49,600	124,800	30,400	106,200	84,000
Non-SMSA Parishes									
St. Charles Parish	18,075	250	4,875	5,700	1,825	1,850	250	1,175	2,150
St. James Parish	8,125	75	1,875	3,050	375	775	125	425	1,425
St. John the Baptist Parish	9,200	150	1,975	2,350	525	1,825	175	925	1,275
Tangipahoa Parish	19,225	150	550	2,700	625	5,825	800	2,225	6,350
Total	740,425	19,825	59,675	93,500	63,150	179,875	42,750	141,450	142,200
Employment Distribution (%)	2/	2.7	8.1	12.6	8.5	24.3	5.8	19.1	19.2
Total Area	864,610	19,937	64,385	121,027	68,434	200,904	46,743	159,270	185,086
Employment Distribution (%)	100.0	2.3	7.4	14.0	7.9	23.2	5.4	18.4	21.4

Sources: Mississippi State University, College of Business and Industry, Division of Research, Mississippi Employment: 1975-1980. University of New Orleans, Division of Business and Economic Research, and the Louisiana State Planning Office, 1981 Statistical Abstract of Louisiana.

Louisiana Department of Labor, Office of Management and Finance, unpublished data.

1/ Data for Louisiana and Mississippi are not altogether comparable due to differences in reporting procedures of the two States.

2/ Totals do not equal 100.0 percent due to rounding.

3/ The Study Area includes only portions of the Biloxi-Gulfport SMSA, and only portions of the Baton Rouge SMSA. The employment distribution includes the entire SMSA's.

Litton Industries, in the Pascagoula-Moss Point area have declined from 25,000 in 1977 to 10,000 in 1983. The retail and wholesale trade and services employment in the Biloxi-Gulfport area reflect the importance of tourism and recreation to the local economy. Government employment in the Biloxi-Gulfport area includes the 3,500 employees currently based at the NASA Space Technology Laboratories near Bay St. Louis. (Plate A-1) In addition to the 17,000 Federal, state, and local government employees working in the Biloxi-Gulfport SMSA in 1980, an additional 16,000 military personnel were stationed in the area.

A.3.8. About 85 percent of the non-agricultural employment in the 10 Louisiana parishes occurs in the New Orleans SMSA. While Ascension and Livingston Parishes are included as part of the Baton Rouge SMSA, non-agricultural employment in these two parishes account for only about 12 percent of the total employment in the Baton Rouge SMSA and only 4 percent in the Louisiana portion of the study area.

A.3.9. As indicated in table A-3-3, about 25 percent of the wages and salaries reported for the New Orleans SMSA was in the retail and wholesale category, reflecting the area's importance as a regional commercial center. About 33 percent of the employment in Orleans Parish was services, indicating the importance of tourism to the city's economy. Manufacturing employment within the New Orleans SMSA, on the other hand, accounted for only about 11 percent. Approximately 25 percent of the employment reported for the non-SMSA parishes, however, was manufacturing. Another 10 percent of the nonagricultural employment in the New Orleans SMSA was transportation and public utilities, reflecting the significance of Port activities. The relatively large amount of public employment in the Baton Rouge SMSA and Tangipahoa Parish include jobs generated by the Louisiana State Government, the Louisiana State University and Southern University in Baton Rouge, and Southeastern Louisiana University in Hammond. (Plate A-11)

A.3.10. In January of 1983 the figures for unemployment in Mississippi and Louisiana were reported to be 12.2 percent and 11.3 percent respectively, somewhat higher than the 10.4 percent estimated for the United States. Unemployment in the two Mississippi SMSA's averaged about 13.0 percent, higher than both state and national averages. Unemployment levels in the Baton Rouge and New Orleans SMSA's were 9.4 and 9.6 percent, respectively. Unemployment in the non-SMSA parishes also averaged 13.0 percent. While the relatively high levels of unemployment may indicate some structural changes from the lower rates of previous years, it is reasonable to assume that much of the current unemployment in the vicinity is part of the cyclical change occurring nationwide. The 1970 Census reported civilian unemployment in the 13 parishes and counties of the study area at about 5.0 percent. Civilian unemployment for the State of Mississippi in 1970 was estimated to be 5.0 percent. For Louisiana, unemployment was 5.4 percent.

A.3.11. The agricultural and forestry sectors had an insignificant percentage of the study area employment in 1980. The fisheries industry is an important source of employment and income for the area. National Marine Fisheries Service (NMFS) reports indicate that in 1981 Louisiana ranked first among the 50 states in total volume of fish and shellfish landings with 1.2 billion pounds. The state ranked fourth in value of landings with $193.5 million, behind Alaska, California, and Massachusetts. Menhaden, a species of fish used for industrial purposes, accounted for 1.02 billion pounds landed in Louisiana although its unit value is relatively low, $39.2 million. Commercial fish and shellfish landings in coastal Mississippi totaled 264.9 million pounds valued at $30.2 million.

A.3.12. Collection of data by NMFS on the pounds and value of the commercial landings in individual Louisiana parishes was discontinued in 1978. Table A-3-4 shows 1978 fish and shellfish landings for the

Louisiana portion of the study area. Most of the fish and shellfish landed in this portion of the study area are shrimp, oysters, crabs, and catfish. The estimated total value represented about 11 percent of the total value of all fish and shellfish landed in the state. These figures reflect the value received by fishermen at the dock.

TABLE A-3-4

COMMERCIAL FISH AND SHELLFISH LANDINGS
IN THE LOUISIANA PORTION OF THE STUDY AREA, 1978 CALENDER YEAR

	Pounds	Value ($)
Shrimp	18,790,000	$18,040,000
Oysters	1,830,000	2,120,000
Blue Crab	4,300,000	1,200,000
Catfish and bullheads	410,000	160,000
Subtotal	25,330,000	21,520,000
% of Total	96	99
Other	920,000	270,000
Total	$26,250,000	$21,790,000

Source: US Dept of Commerce, National Marine Fisheries Service, unpublished data.

A.3.13. Marine fishery landings in Mississippi are all within the study area. Table A-3-5 shows the value and pounds of fish and shellfish landed along the Mississippi Gulf Coast in 1982. Other species not reported in the table but with landings valued at more than $100,000 were mullet, black drum, and croaker.

TABLE A-3-5

COMMERCIAL FISH AND SHELLFISH LANDINGS
IN MISSISSIPPI, 1982 FISCAL YEAR

	Pounds	Value
Shrimp	5,813,000	$17,322,740
Menhaden	260,100,600	10,304,164
Oysters	1,589,000	1,412,700
Red Snapper	747,900	904,959
Blue Crab	1,317,000	355,590
Subtotal	269,567,500	$30,300,153
% of total	98.8	97.6
Other	3,162,600	751,115
Total	272,73[illegible],100	$31,051,268

Source: Mississippi State Department of Wildlife Conservation, "Mississippi Wildlife Conservation Annual Report 1981-1982".

Note: The source used data for the Mississippi Fiscal Year that begins in July. The commercial fishing season begins much earlier in the calendar year. This accounts for variations from data reported elsewhere.

A.3.14. While statistical data on employment generated by sport and commercial fishing activities in the study area are not readily available, the sale of commercial fishing and seafood marketing licenses provides an indication of the importance of the area's commercial fishing industry. The most useful published source of detailed information is the licensing records of the Louisiana Department of

Wildlife and Fisheries and the Mississippi Department of Wildlife Conservation Bureau of Marine Resources. In 1980, commercial fishermen in Louisiana who used commercial-sized trawls were required to be licensed. In Mississippi, fishermen who used a certain size boat were required to be licensed. Sales from licenses issued in 1982 were about $442,000. The majority of all licenses issued were for either commercial or noncommercial shrimping.

A.3.15. The total number of commercial licenses sold within the Louisiana portion of the study area increased from 11,792 in 1978 to 17,828 in 1982, representing a growth of 51 percent over a 4-year period. Table A-3-6 shows a distribution of these licenses. In Louisiana, anyone who intends to sell a shrimp catch is considered to be a commercial fisherman and must purchase a commercial shrimp license. In 1982, there were about 13,628 commercial shrimp licenses issued in the area, including licenses for both trawls and vessels. Sales from the commercial shrimp licenses totaled about $270,000 in 1982. The licenses issued amounted to about 82 percent of the total issued for the state.

A.3.16. In addition to the licensed commercial shrimpers, there are a large number of both licensed and unlicensed sport shrimpers who have other primary sources of income. Shrimpers who do not intend to sell their catch are not required to license their vessels or any trawls under 16 feet long, but their catch is limited to 100 pounds of "heads-on" shrimp per day per boat. However, sport shrimpers who want to exceed the 100-pound limit or use trawls over 16 feet must purchase a noncommercial license. In 1981, nearly 101,000 sport-fishing licenses were sold in the 10-parish area. A large volume of fish and seafood is harvested in the area by unlicensed fishermen.

TABLE A-3-6

COMMERCIAL FISH AND SHELLFISH LICENSE SALES IN THE LOUISIANA PORTION OF THE STUDY AREA, 1982

	Sales	No. of Licenses Sold	% of State Licenses Sold
Saltwater Shrimp Trawls & Vessels	$172,950	7,051	35.9
Saltwater Shrimp Trawls (only)	95,360	6,334	39.1
Saltwater Shrimp Vessels (only)	1,230	243	51.7
Retail Fish and Seafood Dealers	4,440	888	29.7
Wholesale Fish and Seafood Dealers	6,800	136	30.8
Resident Commercial Crab Trap Fishermen	11,025	441	45.2
Oyster Tonnage	861	336	15.2
Oyster Dredging	9,600	192	40.2
Subtotal	$302,266	15,621	23.7
Other	25,615	2,207	3.3
Total	$327,881	17,828	27.1

Source: Louisiana Department of Wildlife and Fisheries, unpublished data.

A.3.17. All vessels used in the commercial harvest of oysters require a state license, regardless of the process used. A second license is required for oyster dredging. No license is required for the tonging of two sacks of oysters per day. In 1982, 336 oyster licenses and 190 oyster dredging licenses were issued in the 10-parish area. Four hundred and forty crabbing licenses were issued during the same period. Many fishermen held various combinations of fishing licenses, primarily commercial shrimping and oyster dredging licenses. Some

fishermen combine fishing with trapping and taking alligators. Fisheries processing and wholesaling plants in Louisiana and Mississippi provided permanent jobs and also employed several thousand part-time workers during peak seasons. Many of these plants are located in the study area.

A.3.18. Sales of marine fishery licenses in Mississippi have increased dramatically over the past 10 years. While the price of the licenses remained unchanged, sales increased from $39,782 in 1973 to $113,643 in 1982. Revenue collected from the sale of commercial shrimping licenses totaled $56,935. Sales of licenses to commercial oyster fishermen totaled $20,325. Other licenses and revenues included seafood dealerships, $17,898; crabbing, $8,760; and all finfish, $2,865. As with the Louisiana shrimpers, there are numerous unlicensed sport shrimpers in Mississippi.

LAND USE

A.3.19. The economic study area covers about 3.96 million acres. (The noneconomic study area is 2.96 million acres.) Commercial forest land accounts for approximately 58 percent, 2,300,000 acres, of the total area. The remaining 1,660,000 acres are distributed between farmlands, wooded swamps, marshes, water bodies, and urban areas.

A.3.20. The Louisiana portion of the study area covers 2,810,000 acres or about 71 percent of the total area. Of this total, about 50 percent is commercial forest land and another 25 percent is cropland and pasture. Most of this land is in the higher elevations north of Lake Pontchartrain. South of these forest and agricultural lands are wooded swamps, marshes, and a series of large shallow lakes. The largest of these lakes is Lake Pontchartrain, covering 640 square miles. Since New Orleans is below sea level, the city must be protected from storms and

[illegible] stages [illegible] of pumps and levees, limiting the availability of land for urban development. As a result of the levees and [illegible] soils are shrinking and subsiding. In some area, elevations [illegible] as low as -10.0 feet. [illegible] urban land and lands used [illegible], account for 5 to 10 percent [illegible] area. The remaining 15 to [illegible] swamp, [illegible], and water bodies.

[illegible] coastal counties in Mississippi, the remaining [illegible] study area, cover approximately 1,150,000 acres and make [illegible] of the total. Of this total, about 897,000 acres or about [illegible] percent is commercial forest land, mostly pine and a mixture of pine and oak. Farmland (excluding woodland) is about 64,000 acres or less than [illegible] percent of the total area. The remaining 15 to 20 percent of the land [illegible] wetlands in St. Louis, Biloxi, and Pascagoula Bays, the Pearl River Basin, and urban developments primarily located along the gulf coast. Most of the commercial and industrial developments are in the Biloxi-Gulfport and Pascagoula-Moss Point urbanized areas. Public lands include the NASA facilities, Keesler Air Force Base, and portions of the DeSoto National Forest. (Plate A-4)

MINERAL RESOURCES AND PRODUCTION

A.3.22. Significant mineral deposits found in the study area include crude petroleum, natural gas, and natural gas liquid. Other resources include cement, clay, salt, sulphur, sand, gravel, lime, and magnesium compounds. These deposits make a considerable contribution to the study area's economy. The total 1977 value of Louisiana's mineral production was about $10.5 billion, of which $5.7 billion was from natural gas and natural gas liquids. Another $4.4 billion was from crude petroleum. In Mississippi, with few petroleum and natural gas deposits, mineral production value was $0.5 billion. The value of mineral production in

1975 by parish and county is shown in table A-3-7. The Bureau of Mines ended its reporting of the value of energy-related minerals by county and parish in 1975. In 1981 about 13 percent of the nation's total crude petroleum production originated in Louisiana. Of this total, about 92 percent was produced in the gulf coast region. The total mineral value of the six Louisiana parishes in 1975 was $911.4 million, or about 1.5 percent of the value of all minerals produced in the United States.

A.3.23. The three Mississippi counties are not as well endowed with minerals as Louisiana. Harrison County has few resources while Jackson County has deposits of magnesium compound and lime. Hancock County has small deposits of natural gas and crude petroleum valued at $384,000 in 1975.

TRANSPORTATION

A.3.24. The area is served by an extensive transportation system. Deep draft navigation access is provided to the Port of New Orleans and industries by the Mississippi River, the MR-GO, and the IHNC. Shallow draft access is provided by many inland waterways including the Gulf Intracoastal Waterway, East Pearl River, Gulfport Ship Channel, and channels associated with Biloxi and Pascagoula Harbors. (Plates A-4 and A-11)

A.3.25. The Port of New Orleans is the world's largest grain port, the largest seaport in the United States, and the second largest in the world in terms of dollar value and waterborne tonnage handled. More than 5,000 ships call at its docks each year. The port serves midcontinent United States where one-third of the nation's population resides. The port handled 70.2 million tons of foreign trade in 1979. Coast-wise traffic was approximately 13.1 million tons and internal

[illegible]	[illegible]	[illegible] gas, sulfur, [illegible], salt.
St. [illegible]	[illegible]	[illegible], natural gas, natural [illegible]
St. [illegible]		[illegible], petroleum, [illegible]
Ascension Parish	[illegible]	[illegible], petroleum, natural gas.
Orleans Parish	3[illegible]	[illegible], shell, lime, natural gas, petroleum.
St. [illegible] Parish	2[illegible]	[illegible], natural gas, natural [illegible].
[illegible]	28[illegible]	natural gas, sand and gravel, petroleum.
Harrison County	[illegible]	sand and gravel.
Jackson County	W	magnesium compounds, lime.
Livingston Parish	W	sand and gravel.
St. [illegible] Parish	W	petroleum, natural gas.
St. Tammany Parish	W	shell, sand and gravel, clays.
[illegible] Parish		sand and gravel, petroleum, clays.
Louisiana	[illegible]	all minerals produced in the State.
Mississippi	310,000	all minerals produced in the State.

Source: US Dept of Interior, Bureau of Mines, [illegible] Bureau of Mines Minerals Yearbook, Vol. II.

W - withheld to avoid disclosure of reports by individual companies.

traffic was about 84 million tons. At any given time, one of every four barges in the United States is in the New Orleans area. The Port of New Orleans comprises 295 piers, wharves, and docks. Twenty-five linear miles of facilities are located along both banks of the Mississippi River. Other facilities are located along the IHNC, Michoud Canal, the MR-GO, the Harvey and Algiers Canal, Bayou Sauvage, and Bayou Barataria.

A.3.26. Other ports in the study area include the Port of Pascagoula and the Port of Gulfport (Plate A-4). Both ports are considerably smaller than the Port of New Orleans, but they make a sizable contribution to their local economy. The Port of Pascagoula has two harbors: Pascagoula Harbor and Bayou Cassotte, Mississippi. The port provides dock and harboring facilities for ocean shipping, barge traffic, commercial fishing vessels, and recreation craft. Bananas and plantains are the main import of the Port of Gulfport. Principal exports are rice, meat, paper, and paperboard products.

A.3.27. Other vital forms of transportation that serve the area include mainland railroads, Federal interstate highways, and Federal and state highways. The New Orleans area is served by six trunk line railroads. In addition, the New Orleans Public Belt Railroad operates as a switching carrier serving all railroads, 160 industries, and the adjacent industrial canals. In Louisiana, the railroads extend along the alluvial ridges as far south as the Gulf Intracoastal Waterway and along the Mississippi River to just below New Orleans. The railroad extends along the entire shore of Mississippi from Louisiana to Alabama.

A.3.28. Major Federal highways include Interstates 10 and 12, running generally east-west and Interstates 59 and 55, north-south thoroughfares. Other Federal highways of significance include US Highways 90 and 190, the primary east-west arteries, and US 11 and 49 to the north. State and local roads make up the bulk of the land

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[illegible] summer-fall, during low river outflow, and lowest in winter-spring, during high river outflow. Table A-3-9 shows the salinity ranges in the three regions of the sound. There is a noticeable westward decreases in salinity in the sound which is caused by greater river outflow in the western sound. In addition, when the Bonnet Carre' Spillway is opened, waters of the Mississippi River deluge the area to about the level of Ship Island.

TABLE A-3-9

HIGH AND LOW SALINITIES DURING SEASONAL RIVER OUTFLOW PERIODS IRRESPECTIVE OF BOTTOM OR SURFACE SALINITY DESIGNATIONS (PARTS PER THOUSAND)

	West Sound		Central Sound		East Sound	
	Coast	Passes	Coast	Passes	Coast	Passes
Low River Outflow	16	30	20	30	30	34
High River Outflow	2	8	4	20	4	18
Average	10	20	18	26	16	30

Source: (Eleuterius, c. 1977)

WATER QUALITY

A.3.62. The water quality of water bodies in the study area is, to a large extent, affected by land uses in the drainage areas of the water bodies. Municipal, industrial, and vessel wastes, urban stormwater, agricultural and silvicultural runoff, and water-oriented recreation and camps can adversely affect water quality. In general, though quality of water in the water bodies is marginal, conditions have improved in recent years.

far east as a line [illegible] Island. The waters discharged from the [illegible] eastward flow.

A.3.59. Circulation patterns west of Cat Island are influenced by winds and freshwater inflows from the Pearl, Jordan, and Wolf Rivers. The direct exchange of west Mississippi Sound waters with the open gulf is practically nonexistent. Water exchanges through Cat Island Pass are largely from Chandeleur and central Mississippi Sounds. The waters of Lake Borgne and the Mississippi Sound are exchanged through three passes: Le Petit Pass, St. Joe Pass, and the unnamed pass between Half Moon Island and Le Petit Pass.

SALINITY

A.3.60. Salinity regimes in Lake Pontchartrain varied from no measurable salt content to 11.0 parts per thousand (ppt) with an average of 4.0 ppt. These extremes were recorded at opposite ends of the estuary. The high was recorded at the eastern-most station located in Lake Pontchartrain near the more saline waters of Lake Borgne, while the lowest salinity level was recorded at the western-most station in Lake Maurepas. Tidal action and, more importantly, wind velocity and direction were responsible for the fluctuations in salinity. During an outgoing tide, wind action from the opposite direction prevents any sizable change in water depth. Depending upon wind direction, the lakes may be either more saline or practically fresh for several days. Generally, the highest salinities were recorded during October and November; the lowest during March and April.

A.3.61. Salinities in the Mississippi Sound are highest near the Barrier Island passes and deep channels and lowest near the water surface and next to the coast proper. Generally, salinities are highest

tides is a littoral drift to the west along the south and north shores, and a return current in a broad band of water running approximately from the northwest to the southeast (plate A-3). Center currents and eddies exist in the lake that may modify this pattern. Discharging Mississippi River waters through the Bonnet Carre' Spillway markedly changes the circulation pattern in the lake to an easterly flow near the south shore and mid-lake. An estimated 57 percent of water transported in and out of the lake passes through the Rigolets; 32 percent passes through Chef Menteur Pass, and 6.5 percent through the IHNC. Major rivers and streams contribute the remaining 4.5 percent of the lake's inflow.

A.3.57. The water circulation patterns in the Mississippi Sound are quite variable and complex and are influenced by geometric, bathymetric, and wind conditions. In general, the net current movement is slow toward the west (plate A-4). Eleuterius (1973, 1976) has shown that the Mississippi Sound is characterized by three recognizable hydrologic regimes. The eastern sound is dominated by water inflow from Mobile Bay and Petis Bois Pass. The central sound has little freshwater inflow and the water characteristics are largely defined by the flux through the central passes. The western sound is fed by fresher water from Lake Pontchartrain, Pearl River, and Bay St. Louis. It is connected with the gulf shelf through the marshes. Tidal exchange through passes at the western tips of the barrier islands maintains deep channels in these areas that are extensively used by migrating marine life species.

A.3.58. Five passes between the barrier islands allow seawater to intrude into the Sound and mix with freshwater inflows from major streams. Circulation in the central Mississippi Sound is largely attributed to tidal flux through Dog Keys and Ship Island passes. The tides entering through the two passes converge along an approximate north-south line bisecting Camille Cut. Bonnet Carre' Spillway openings alter the normal circulation patterns and have influenced the area as

A.3.54. The tides in the estuaries are chiefly diurnal with one high and one low tide in a day. The tide ranges from 0.9 to 1.9 feet. The normal tide range is about 0.3 feet in Lake Maurepas, 0.5 feet in Lake Pontchartrain, 1.2 feet in Lake Borgne, 1.4 feet in Chandeleur Sound, and 0.9 feet in Mississippi Sound. Water levels generally are at their lowest in early winter, rise through mid-spring, decline slightly through early summer, rise to a peak in late summer, and then decline through the fall. The range and height of the tides is frequently modified by the wind. Strong southerly winds raise water levels about 1 to 5 feet above normal and hurricanes have produced tides in excess of 22 feet. Conversely, northerly winds blow water out of the estuaries, depressing water levels 1 to 2 feet below normal.

A.3.55. Water movements within the estuaries are influenced by the winds, tides, freshwater discharges, and currents in the gulf. Currents immediately south of the barrier islands flow counterclockwise from mid-summer to early winter. From mid-winter to early summer the currents flow toward the north and east but freshwater discharges and the winds modify this pattern. The current velocities usually range between 1.5 and 4.0 feet per second (fps), but strong tides increase the velocities in the vicinity of the passes to 8.5 fps. The littoral drift in Chandeleur Sound is generally toward the north; in Mississippi Sound, the drift is toward the west. Current velocities range from 0.5 fps to 4.2 fps in the deeper passes but are greater during high water discharges and extreme spring tides.

A.3.56. The water circulation in Lake Pontchartrain is dominated by an easterly wind with either a northern or southern component depending on the season. Wind speeds greater than 15 mph, occurring about 15 percent of the time, cause bottom sediments to become stirred and mixed throughout the water column, and often impart a brownish color to the water. The general water circulation pattern for both flood and ebb

the Mississippi Sound. The sound receives most of the freshwater inflows from the Wolf, Jordan, Biloxi, Tchoutacabouffa, and Pascagoula Rivers. Their combined watersheds contribute an estimated average annual discharge of 24,500 cfs. Pertinent data on major streams in the study area is shown below:

Major Stream	Period of Record	Discharge (1000 cfs) High	Mean	Low
Mississippi River at Tarbert Landing	1973-80	1,500	537	160
Amite River NR Denham Springs	1938-81	110	1.98	0.27
Tickfaw River at Holden	1940-81	19	0.37	0.07
Tangipahoa River at Robert	1938-81	50.5	1.13	0.25
Tchefuncte River NR Folson	1943-80	29.2	0.16	0.03
Pearl River NR Bogalusa	1938-80	129	9.77	1.02
Wolf River NR Landon	1971-80	15.8	0.74	0.04
Jordan River at at Santa Rosa	1962-66	16.6	N/A	0.01
Biloxi River at Wortham	1952-80	8.42	0.19	0.001
Tchoutacabouffa River at Tuxachanie	1952-66	17.7	0.19	0.002
Pascagoula River at Merrill	1930-80	178	10.0	0.70

Sources:
1. Water Resources Data - Louisiana 1981
2. Water Resources Data - Mississippi 1980
3. Lower Mississippi Region Comprehensive Study

A.3.51. In the fall and winter, the prevailing winds are from the northeast but in the spring and summer, they shift direction and come from the southeast. The average wind velocity is 8 miles per hour (mph) in the fall, increasing to 9 mph in the winter and spring and decreasing to 6 mph in the summer. The strongest winds are associated with the high pressure systems that penetrate the gulf area in winter, and with hurricanes in summer. Winter storms have produced wind speeds of up to 47 mph and hurricanes have generated winds in excess of 190 mph in the area. Since 1900, 45 tropical storms and hurricanes have crossed the study area.

A.3.52. Monthly mean relative humidities are high throughout the year. Seasonal variations because of the influence of the gulf waters are negligible. Maximum values of the monthly mean occur during spring, the time of greatest consistency of southeasterly winds. Minimum humidities occur during the fall.

HYDROLOGY

A.3.53. The drainage system in the study area is comprised of bayous, rivers, and canals that drain into a series of interconnected lakes, bays, and sounds. All are influenced by tides. The streams are characterized by their meandering pattern and sluggish flows. Major streams in the study area that discharge into Lakes Maurepas and Pontchartrain include the Amite, Tickfaw, Tangipahoa, and Tchefuncte Rivers. Lake Pontchartrain also receives freshwater inflows from the Mississippi River during Bonnet Carre' Spillway openings. The major streams contribute an average annual flow of 3,600 cubic feet per second (cfs). The water from Lake Pontchartrain enters Lake Borgne via Chef Menteur Pass and the Rigolets and a portion enters the MR-GO via the IHNC and then into Chandeleur Sound. Lake Borgne receives an average annual flow of 9,800 cfs from the Pearl River. Part of this flow enters

spring and summer. Frequently, westerly winds in summer or northerly winds in winter interrupt the normal pattern, and drier weather results. Rainfall is abundant with an annual normal precipitation of 61.0 inches (1941-1970). In a normal rainfall cycle, rainfall activity is at a minimum in the fall with 12.2 inches, rises in the winter t 15.5 inches, declines in the spring to 14.4 inches, and rises to a maximum of 19.0 inches in the summer. The wettest month is July with 7.1 inches of rain primarily as a result of frequent thundershowers. September and March are next in amounts of precipitation with 6.0 inches and 5.9 inches, respectively. The driest months are October and November when the dry continental air masses push southward over the area causing clear skies and cool nights.

A.3.49. Snowfall occurs only rarely. Evaporation studies indicate that losses from the water bodies average 45.3 inches annually. Approximately 70 percent of the evaporation occurs in the spring and summer months.

A.3.50. The winds are influenced by the pressure systems over the gulf and the continent. The winds over the area follow the sweep of the western extension of the Bermuda High during the spring and summer months. High pressure systems over the North American continent modify the patterns for the remaining months. These high pressure systems and their associated extratropical cyclones are responsible for wide pressure ranges of winter. The Bermuda High has greater constancy than the continental high pressure systems so it maintains a rather steady flow of warm, moist air in late spring and summer that controls the climate over the area to a large degree. Periods of good weather tend to be longer during late spring and summer than during late fall, winter, and early spring. The monthly mean pressures range from a maximum of 30.1 inches of mercury in December and January to a minimum of 29.97 in September. A low of 26.6 inches of mercury was estimated when Hurricane Camille passed over the study area in August 1969.

TABLE A-3-8

MONTHLY DISTRIBUTION OF WATER TEMPERATURES

	Miss. Sound (Surf. Augs.)		Shelf								
	Mainland	Barrier Islands	5-fm contour			10-fm contour			20-fm contour		
			S*	M-D*	B*	S*	M-D*	B*	S*	M-D*	B*
JAN	12.4	9.4	12.3	12.6	14.9	13.9	14.2	16.0	15.7	17.5	18.5
FEB	14.5	13.0	13.5	11.7	14.5	16.6	16.8	17.1	16.5	16.5	17.0
MAR	13.4	16.8	15.9	13.4	15.5	22.4	22.2	20.2	20.9	19.0	18.5
APR	25.3	25.8	23.2	25.0	21.7	25.1	24.3	22.6	24.2	23.5	22.0
MAY	18.0	26.9	25.5	25.0	24.7	29.5	30.5	24.0	29.4	25.0	25.0
JUN	30.3	30.8	29.9	31.0	29.5	29.9	26.9	27.0	30.4	30.4	27.3
JUL	29.1	30.4	30.3	29.7	29.0	29.6	30.0	29.0	30.8	31.0	29.0
AUG	30.7	30.3	29.0	29.0	29.0	28.9	28.0	27.6	28.2	27.9	28.0
SEP	29.5	30.2	26.5	26.0	26.4	25.1	25.4	24.9	27.2	28.1	27.1
OCT	22.6	21.6	23.7	22.7	20.4	19.5	17.5	22.2	19.0	18.7	17.6
NOV	19.0	18.5	17.2	17.3	17.6	16.2	16.2	16.2	16.9	17.2	17.8
DEC	12.9	14.9	14.0	14.2	14.5	22.7	22.0	21.8	22.8	22.7	22.2

S* - Surface
M-D* - Mid-depth
B* - Bottom

Source: Mississippi Sound and Adjacent Areas, Dredged Material Disposal Study (Stage 1) Reconnaissance Report, Appendix A, resource inventory, US Army Corps of Engineers, Mobile District, March 1979.

Note: Monthly distribution of water temperature at selected localities in the study area. Mississippi Sound values were all taken in shallow water (Christmas, 1973). Shelf data are from a transect proceeding southeasterly from the Horn/Ship Island Pass (Franks, et. al., 1972).

CLIMATE

A.3.45. The climatic conditions in the study area are affected by the tropical air masses over the Gulf of Mexico in the spring and summer (April through September) and by cold air masses over the continent in the fall and winter (October through March). These factors produce a climate with a humid, subtropical hot summer, heavy precipitation, and generally high humidity. Average monthly temperatures range from a high of 27.2°C (81°F) in summer to a low of 10.5°C (51°F) in winter with an annual normal temperature of 20°C (68°F) for the period 1941-1970.

A.3.46. Seasonal water temperatures in Lake Pontchartrain vary from 7.0°C (44.6°F) in January to 32.9°C (91.2°F) in June. The average temperature is about 20.7°C (69.3°F). Water temperatures below 10°C (50.0°F) are infrequent. The high temperature recorded exceeds the temperatures in the shallow lagoons and near beaches during the summer.

A.3.47. The Mississippi Sound temperatures average 30°C (86.0°F) in the summer months. During the winter months the water temperature may fall below 13°C (55.4°F). The northern gulf coast near shore surface water temperature closely approximates the air temperature. Since the Mississippi Sound is well mixed, the bottom water temperatures of this area often closely conform with those at the surface. Both surface and bottom waters of the sound undergo substantial seasonal fluctuation. Table A-3-8 shows monthly distribution of water temperature.

A.3.48. Major rainstorms are associated with tropical disturbances and hurricanes in summer and early fall, and with frontal activity incident to the extratropical cyclones in late fall, winter, and spring. Convective thundershowers produce intense but localized rainfall in late

A.3.43. Swamp deposits consist of organic clays with scattered lenses of silt and peat layers. They have an organic content of less than 30 percent, a high water content, and a soft consistency. Maximum thickness of approximately 22 feet can be found near areas of active stream deposition. Marsh deposits consist of a thin root mat located just below the water surface. Below this mat, there is a zone of gray to black ooze composed of very fine granular and fibrous organic matter with varying amounts of clay and thin layers of peat scattered throughout. The organic content ranges from 20 to 50 percent of the sample. Water content of marsh deposits can exceed five times the dry weight of the sample. Thickness of marsh deposits vary but generally range from 5 to 10 feet. Natural levee deposits located along the Mississippi River generally range from 8 to 12 feet thick at the levee crest. Generally, the coarsest material is found at the levee crest and consists of firm to stiff silty clays with lenses of silt scattered throughout. The organic content found in natural levee deposits increases away from the levee crest and towards the swamp and marsh deposit. Small natural levees of the larger streams which drain the uplands (Prairie Terrace) north of the basin are composed of very silty to sandy clay. Thicknesses generally vary from 2 to 4 feet. The natural levees may be 200 to 300 feet wide.

A.3.44. Soils in the Mississippi portion of the study area are generally poor to moderately drained sandy clays and loams. The Mississippi Sound sediments are composed mostly of silt and clay with some areas of fine to medium sand. Fine sands, silts, and clays border the mainland east of Pascagoula. Medium and coarse sands dominate the mainland beaches west of the Pascagoula River and along the leeward side of the barrier islands. These areas seaward of the island are mostly fine sands except for a notable, elongated mud area just off Dauphin Island.

9 miles offshore. From east to west, the islands are Dauphin, Petit Bois, Horn, Ship, and Cat Islands. The islands are separated from one another by 3 to 6 miles of open water, most of which overlies a fairly shallow sand bottom or bar.

A.3.40. Lakes, bays, and sounds cover approximately 70 percent of the study area. The major water bodies are Chandeleur Sound with 578,000 acres, Mississippi Sound with 526,000 acres, Lake Pontchartrain with 394,130 acres, Lake Borgne with 171,380 acres, and Lake Maurepas with 58,190 acres. The configuration of water bodies varies considerably but, in general, the lakes are circular to oval, the bays are triangular, and the sounds are rectangular. The shorelines of the lakes are usually smooth while those of the bays and sounds are irregular and indented. The lakes are generally flat-bottomed and shallow with average natural depths of 1 to 12 feet. The greatest depth occurs in the tidal passes and navigation channels.

A.3.41. Elevations in the wetlands, which make up most of the land area, range from slightly below to just above National Geodetic Vertical Datum (NGVD). The lowest elevations occur within the New Orleans metropolitan area where the ground is commonly several feet below sea level. High elevations occur on the natural levees and on some relict beach/dune ridges inland from the Mississippi coastline. The highest ground elevation of 30 feet occurs on the crests of the artificial levees along the Mississippi River.

SOILS

A.3.42. Landforms within the Pontchartrain basin are principally swamp, marsh, and natural levee. Soil or soil types that characterize or are normally associated with these landforms vary from highly organic to inorganic silts, highly plastic clays, lean clays, sandy silts and minor amounts of sands.

is 11.7 feet. The width of the sound varies from 7 to 15 miles and its longitudinal length is about 83 miles.

A.3.37. The Mississippi coastal zone geologic units exposed in the study area are late Pleistocene and Holocene. These units are founded on the same gently gulfward-dipping Prairie coastwise terrace deposits that are encountered in the Louisiana portion of the study area. The fluvial Prairie sediments are mostly sand and silty units deposited in floodplains, river channels, oxbow lakes, and natural levees.

A.3.38. Overlying the Prairie and older Pleistocene formations are deposits associated with three late Pleistocene barrier ridge segments in coastal Mississippi. These have been named "Gulfport" formation and are composed mainly of medium- and fine-grained white sand although lesser amounts of silty sand are also present. Sets of numerous parallel beach ridges with intervening low areas occur both in the Harrison County and Bellefontaine areas. Their cores are limonized and they are usually veneered by Holocene Beach and dune deposits and marshes. These Gulfport ridges probably were originally a beach/dune complex along the Pleistocene shoreline. The complex is recognized as far east as the Mobile (Alabama) Point peninsula and as far westward as Lake Pontchartrain.

A.3.39. As the glacier retreated after the late Wisconsin Glacial stage, the rising sea encroached over the presently submerged coastal-nearshore zone. The offshore barrier islands probably are the result of aggradation of submarine shoals. These islands consist entirely of fine- to coarse-grained sands carried by littoral drift from the east (Alabama mainland shores). In places, the sand islands are founded directly on Holocene marine or lagoonal deposits similar to the present back bay deposits of Mississippi Sound. The island chain is approximately 66 miles long and about 1/2-mile wide and lies approximately

[illegible] Plate [illegible]

A.3.[illegible] [illegible] sedimentary [illegible] Islands. The [illegible] easterly [illegible] eastern New [illegible] tributary [illegible] the last [illegible] distributary mouths [illegible] the delta [illegible] delta to form [illegible] distributary areas [illegible] end of the [illegible] Islands. The [illegible] and lies [illegible] prominent features [illegible] River distributaries, [illegible] and the barrier islands.

A.3.3[illegible]. The [illegible] relatively large shallow basin with a surface area of [illegible] square miles at mean low water. The average depth

edge of the continental shelf that were reworked and redeposited in place as the sea level rose at the end of the last glacial epoch. Materials from both sources were reworked by marine processes and deposited as a distinct zone overlying the buried Prairie (Pleistocene) surface during the early history of the basin.

A.3.31. The greatest portion of the basin's history (the last 4,000 years) was characterized by active sedimentation from the Mississippi River. Clays, silty clays, silts, and small quantities of very fine sand were deposited as a result of major shifts in the courses of the river. The resulting sedimentary unit is in the form of a seaward-thickening wedge that overlies and almost completely covers all features of the previous marine zone.

A.3.32. The basin was formed as the geologically older Pleistocene deposits subsided and the Gulf of Mexico encroached, creating a shallow marine embayment. Sediment contributions from the Mississippi River ceased when the river formed a delta with a natural levee system across the southern margin of the embayment, severing its connection with the open gulf. Deprived of sediment inputs, the basin continued to subside and the lakes expanded rapidly to their present configuration. The most prominent features of the basin are outcrops of Pleistocene deposits, the natural levees of the Mississippi River and its distributaries along the northern shore of Lake Pontchartrain, and the marsh areas along the south, southeastern, and northeastern shorelines.

A.3.33. Lake Pontchartrain, largest of the brackish water lakes in Louisiana, is the focal point of the basin. This shallow lake (average depth of 12 feet) covers an area of about 640 square miles. Water in the lake today is a mixture of fresh water that enters from the upland areas to the north, and saline water that intrudes from the gulf through the Rigolets, Chef Menteur Pass, and the IHNC via the MR-GO.

A.3.63. Within the study area the Mississippi River is designated by the Louisiana Environmental Control Commission for secondary contact recreation, propagation of fish and wildlife, and domestic raw water supply. The river has been classified "water quality limited" due primarily to consistently high total and fecal coliform bacteria densities and recurrent taste and odor problems associated with phenolic compounds. Violations of DO, chloride, sulfate, TDS, pH, and temperature standards have been very infrequent.

A.3.64. State standards do not limit ambient nitrogen and phosphorous concentrations. Two forms of these macronutrients are of particular significance in the quality characterization of a water body: un-ionized ammonia because of its toxicity to aquatic life, and phosphate because of its role in the accelerated aging and enrichment of lakes and estuaries. The US Environmental Protection Agency (EPA) recommends in its Quality Criteria for Water that un-ionized ammonia concentrations not exceed 20 ug/l for protection of freshwater aquatic life. To prevent the development of nuisance biological growth and control accelerated or cultural eutrophication, the EPA also recommends that total phosphate as phosphorus not exceed 50 ug/l in any stream at the point where it enters any lake or reservoir. The EPA criteria recommends further that total phosphorus not exceed 100 ug/l in streams not discharging directly to lakes or impoundments. Un-ionized ammonia concentrations computed from total ammonia, temperature, and pH data for the Mississippi River at New Orleans exceeded the EPA criterion in 80 of 337 samples (24 percent). Ninety-two percent (199 of 216) of the phosphate observations from samples collected in the river between miles 155 and 75 exceeded the 50 ug/l criterion and 94 percent (568 of 605) of the total phosphorus observations exceeded the 100 ug/l criterion. Although phosphorus concentrations in the river consistently exceed EPA recommendations, phosphorus is not a problem because the river's swift currents and the absence of quiet zones with poor circulation retard outbreaks of algal blooms.

A.3.65. The trace metals copper, zinc, and iron have been detected in the Mississippi River near New Orleans at concentrations of 1.1, 2.2, and 15.1 mg/l, respectively. Even with the enormous dilution capacity of the river, trace metals concentrations at these levels are cause for concern. Such high concentrations indicate the impact of industrial and urban stormwater discharges to the river. A review of water quality data indicates that the trace metals cadmium and copper consistently exceed the EPA freshwater aquatic life criteria. The data indicate further recurrent exceedances of the EPA criteria for mercury, zinc, and lead.

A.3.66. The most frequently detected of the phenoxy herbicides, organochlorine, and the organophosphorus insecticides are 2,4-D, dieldrin, and diazinon, respectively. One sample of pesticide concentration in fish tissue indicated a concentration above the corresponding Food and Drug Administration (FDA) action level. This sample, taken at river mile 227 AHP, had a chlordane residue concentration that exceeded the FDA action level of 300 parts per billion.

A.3.67. Lake Maurepas is reserved for primary and secondary contact recreation and for the propagation of fish and wildlife. All parameters analyzed were in compliance with the state criteria except for occasional chlorides, pH, and coliform criteria exceedances. Recorded values of coliform, cadmium, copper, toxaphene, DDT, PCB, and mercury occasionally exceeded the EPA criteria for aquatic life. All of these parameters exceeded the EPA water quality criteria less than 10 percent of the time except for mercury and copper, which exceeded the criteria 38 and 39 percent of the time, respectively. The low pH recorded is attributable to the tributaries and surrounding marshes that are naturally acidic. DO and fecal coliform violations have been noted by the Louisiana Environmental Control Commission in St. John the Baptist Parish drainage canals that flow into Lake Maurepas. These violations are caused by municipal wastes.

A.3.68. Along the north and west shores of Lake Pontchartrain, concentrations of constituents analyzed are within the state water quality criteria except for occasional DO, pH, and fecal coliform violations. The EPA criteria were occasionally exceeded by concentrations of chlordane, DDT, Dieldrin, PCB, mercury, and copper at or near the mouth of feeder streams to the lake. Water quality is slightly improved away from the shores toward the middle of the lake. The Environmental Control Commission has classified the south shore of the lake as "water quality limited" because of coliform and dissolved oxygen violations. The urban areas of Kenner, Metairie, and New Orleans adjacent to the lake pump their urban stormwater runoff into Lake Pontchartrain and studies have indicated that severe violations of coliform and dissolved oxygen correspond with heavy rainfall. In addition, urban areas in Jefferson Parish discharge municipal waste into stormwater drainage canals that eventually pump into Lake Pontchartrain. Jefferson Parish has proposed to construct, under an EPA facility construction grants program, a regional wastewater treatment facility that will have an outfall to the Mississippi instead of into the stormwater drainage canals. The lack of Federal funds in the grant program has delayed construction of the regional facility.

A.3.69. Highly turbid water is characteristic of the Louisiana estuaries. In the warmer months, the water in Lake Pontchartrain is relatively clear and the secchi disc values range from 10.0 and 10.5 feet. Turbidity levels of 1.0 and 1.5 feet were much more frequently recorded during the other months. The average secchi disc value was 3.8 feet. Dredging operations in Lake Pontchartrain increase the turbidity in the immediate vicinity of the dredging vessel. This turbidity dissipates within a few hours and does not affect the transparency of the water within 0.5 miles of the dredge.

A.3.70. Lake Borgne is classified for primary and secondary contact recreation and for the propagation of fish and wildlife. Water quality data indicate that state and EPA water quality criteria are occasionally exceeded by DO, pH, and total coliform.

A.3.71. The IHNC is currently classified as "water quality limited" due to frequent coliform violations. Urban stormwater runoff and vessel wastes are primary sources of pollution in addition to the interchange of flow with Lake Pontchartrain, the Gulf Intracoastal Waterway, and the Mississippi River.

A.3.72. The MR-GO is classified for secondary contact recreation and for the propagation of fish and wildlife. Because the MR-GO is in close proximity to oyster leases in Lake Borgne and coliform counts frequently exceed the state water quality criteria, this water body is classified as "water quality limited." The EPA water quality criteria are occasionally exceeded by mercury, copper, DDT, zinc, PCB and dieldrin concentrations.

A.3.73. The Mississippi Sound is classified for recreation. The general water quality is considered good; however, localized water quality problems exist where the lower reaches of rivers enter the sounds and the bays. The Biloxi Bay estuary is considered polluted from a bacterial standpoint and is nutrient-enriched, reflecting the consequences of heavy municipal and industrial development on a relatively small body of water that is inadequately flushed by the tides. Although the bays are classified for shellfish harvesting, they have been permanently closed because of the high coliform count.

A.3.74. On the Pascagoula-Escatawpa River system, the lower reaches are classified for agricultural and industrial usage. The lower Escatawpa River is polluted due to inadequately treated waste from the Moss Point

industrial complex. Fish inhabit the area only during part of the winter and spring and fish kills sometimes occur as the seasons change. The Pascagoula River is moderately polluted, receiving the untreated wastes from seafood processing plants, a pet food processing plant, and two inadequate municipal sewage treatment plants. In addition, wastes associated with the harbor facilities and shipbuilding operations are discharged in this area. The West Pascagoula River is of relatively good quality with small localized problems resulting from residential development. Bayou Casotte, classified for agricultural and industrial usage, is polluted by a harbor, a refinery, a fertilizer plant, and a chemical operation. Waste discharged into the bayou has created temperature, bacteria, and pH problems.

BIOLOGICAL RESOURCES

BOTANTICAL

A.3.75. Plant life in the study area is diverse. Bottomland hardwood and cypress tupelogum forests and agricultural crops are found adjacent to the natural levees of the Mississippi River and its abandoned courses. As the distance from the river increases, plant types range from wooded swamps to fresh, intermediate, brackish, and saline marshes. Along the Mississippi Gulf Coast, bottomland hardwoods, swamps and marshes are found adjacent to the lower reaches of major rivers and bays entering the Mississippi Sound. All common names of plants mentioned in this appendix follow Montz (1975a, 1975b) and are listed in Section I of Appendix D, Natural Resources. All estimates of habitat acreage provided in this section are based on 1978 conditions.

A.3.76. Marshes. The marshes are classified as fresh, intermediate, brackish, and saline. The distribution of marsh types is shown on plate A-5. Fresh marsh has a mean salinity of 1.0 ppt and is generally

located between wooded swamps and intermediate marshes. In Louisiana, common vegetation in the fresh marsh includes bulltongue, water hyacinth, pennywort, alligatorweed, sawgrass, water hyssop, royal fern, maidencane, cattail, and deerpea. Vegetation typical of the Mississippi fresh marshes includes blunt spikerush, squarestem spikerush, softstem bulrush, swamp lily, lizard's tail, southern blue flag, three-cornered grass, pickerelweed, wildrice, royal fern, and cutleaf mermaidweed, with gulf spikerush being the dominant plant species. There are 36,470 acres of fresh marshes in the study area, 32,970 in Louisiana and 3,500 in Mississippi.

A.3.77. Intermediate marshes are located between fresh and brackish marsh and have a mean salinity of 3.3 ppt. These marshes are characterized by a diverse plant community composed of wiregrass, cyperus, bulltongue, deerpea, roseau, smartweed, wild millet, three-cornered grass, bullwhip, and sawgrass. Intermediate marshes in Mississippi contain homogeneous stands of rushes in higher areas while deeper marshes often contain softstem bulrush. Other species include black rush, pickerelweed, swamp lily, gulf spikerush, three-cornered grass, bulltongue, and sawgrass. The study area contains 41,762 acres of intermediate marshes, 25,377 in Louisiana and 16,385 in Mississippi.

A.3.78. Brackish marshes occur between the intermediate and saline marsh zones. Mean salinity in brackish marshes is 8.1 ppt. Brackish marshes are the most extensive in the study area. There are about 157,604 acres, 137,662 in Louisiana and 19,942 in Mississippi. The marshes are dominated by wiregrass, with saltgrass, oystergrass, dwarf spikerush, widgeongrass, hogcane, black rush, three-cornered grass, and leafy threesquare also common. Brackish marshes in Mississippi support black rush, hogcane, wiregrass, marsh boltonia, sea-lavender, three-cornered grass, saltmarsh morning glory, saltmarsh lythrum, and bulltongue.

A.3.79. Average salinity in the saline marshes is 18.0 ppt. The study area contains 83,711 acres, 56,386 in Louisiana and 27,325 in Mississippi. Saline marshes are generally located adjacent to large lakes, bays and the open gulf, as well as the leeward side of barrier islands. Oystergrass is the dominant saline marsh plant in Louisiana. Black rush, glasswort, saltwort, black mangrove, and saltgrass are also abundant. In Mississippi, homogenous stands of oystergrass are bordered by stands of black rush and may be interspersed with species such as hogcane and three-cornered grass.

A.3.80. The marshes play a vital role in fish and wildlife productivity. Marshes produce large amounts of organic detritus that is transported into adjacent water bodies. Detritus is a very important component of the estuarine food web and is important in maintaining the high level of fishery productivity. The role and importance of detritus in the estuarine food web is well documented by Darnell (1961) and Odum et al. (1973). Marshes and associated shallow water bodies are used by various life stages of many estuarine-dependent species that take advantage of the protection from predators, warmer temperatures, favorable salinity regimes, and the rich detrital food chain. Many important sport and commercial species depend on the shallow marsh areas including the Atlantic croaker (Rogers, 1979), menhaden (Simoneaux, 1977), brown and white shrimp (White and Boudreaux, 1977), and blue crab (More, 1969). Conner and Truesdale, (1973), demonstrated the value of shallow marsh habitat to juvenile brown and white shrimp, gulf menhaden, Atlantic croaker, sand seatrout, and southern flounder.

A.3.81. The marsh also provides habitat for birds. Many birds nest and spend their entire lives in the marshes. Some birds, however, frequent the area only for food. Coastal Louisiana winters approximately 4 million ducks and geese. For migratory birds, the marshes serve as temporary feeding stops. Mammals that live in the marsh include small

rodents, and furbearers such as nutria, muskrats, otters, mink, and raccoons. Numerous reptiles and amphibians live within and are dependent on the marsh including snakes, turtles, lizards, and frogs. The fresher marshes are the preferred habitat of the once endangered American alligator.

A.3.82. The marsh root system protects banks and beaches from erosion. During hurricanes and storms when the marsh is inundated, waves traveling through or over the marsh are greatly reduced or completely dissipated by the friction of the grass surfaces. This frictional barrier also reduces the damages to urban areas that would otherwise be caused by waves.

A.3.83. When surface runoff flows through the marshes, the lag time from the upper basin to the gulf is extended increasing the storage capacity of the areas and moderating the salinities. Slowing the runoff allows sediments to fall out. This sediment disposition offsets erosion and subsidence and has historically resulted in land building.

A.3.84. Marshes assimilate some chemical constituents that occur at abnormal levels as a result of domestic and industrial discharges and stormwater runoff. Without these marshes the assimilative capability of the estuaries would be diminished and the possibility of contaminating fish and wildlife would be increased.

A.3.85. Wooded Swamps. There are about 188,669 acres of wooded swamps in the area, 155,507 in Louisiana and 33,162 in Mississippi. This habitat type consists of semipermanently flooded, forested wetlands and is generally found inland from the fresh marshes. The largest acreage of wooded swamp is in the western portion of the Lake Pontchartrain Basin between the Mississippi River and the western shore of Lake Pontchartrain. The Pearl River swamps are also extensive and

substantial wooded swamps are located in the lower portion of the Pascagoula River system.

A.3.86. Dominant vegetation in the wooded swamps includes baldcypress, tupelogum, red maple, Drummond, and green ash. Other species include pumpkin ash, Carolina ash, blackgum, black willow, water elm, and a variety of shrubs such as Virginia willow, palmetto, buttonbush, peppervine, wax myrtle, and titi. Dominant herbaceous vegetation includes alligatorweed, swamp lily, and lizard's tail. Other herbaceous plants of these swamps are spiderlily, sedges, smartweed, cattail, water hyssop, and water paspalum. Aquatics that can be found in standing water include frogbit, water hyacinth, duckweed, watermeal, and great duckweed. Wooded swamps are productive fish and wildlife habitats and serve an important hydrologic function by storing and regulating the flow of fresh water to marshes and estuaries seaward.

A.3.87. Bottomland Hardwood Forest. This habitat type is found at slightly higher elevations than wooded swamp along the natural levees of the Mississippi River and the floodplains of other major rivers. There are about 90,732 acres in the study area, 48,338 in Louisiana and 42,394 in Mississippi. Seasonal flooding occurs over portions of these forests.

A.3.88. Common tree species in bottomland hardwood forests include American elm, black willow, cottonwood, sycamore, hackberry, water oak, overcup oak, red bay, Nuttall oak, live oak, green ash, mayhaw, water locust, sweetgum, honey locust, and some baldcypress. Shrubs and vines include palmetto, deciduous holly, elderberry, waxmyrtle, eastern baccharis, rattan vine, ladies eardrops, greenbriar, trumpet creeper, crossvine, poison ivy, Virginia creeper, marsh elder, rattlebox, and various sedges and grasses. Bottomland hardwoods are valuable for wildlife production.

A.3.89. Seagrass beds. Extensive beds of submerged vegetation (seagrass beds) occur in Mississippi Sound, especially on the leeward side of Ship, Horn, and Petit Bois Islands. The primary plant species comprising these communities include shoalgrass, turtlegrass, manateegrass, and algae (red and brown). Widgeongrass is also reported to be abundant in the Mississippi Sound area (Eleuterius, 1973). Seagrass and seaweed beds in Mississippi Sound were reduced in size following Hurricane Camille in 1969 (Eleuterius and Miller, 1976). Vegetation decline was probably related to hurricane-caused erosion and sedimentation followed by salinity declines resulting from prolonged floodwater runoff.

A.3.90. In the Louisiana portion of the study area, seagrass beds are primarily limited to the leeward side of the Chandeleur Islands from North Point westward to Freemason and North Islands and south toward Curlew Island (Burk and Associates, Inc., 1977). A brackish submerged vegetation assemblage is found in concentrations within the Lake Pontchartrain Basin (Montz, 1975). The most abundant species are wildcelery, widgeongrass, and southern naiad. The greatest concentration of these submerged plants is found in the shallow waters near the northeastern shore of Lake Pontchartrain and is believed to be approximately 2,000 acres in extent.

A.3.91. Agricultural lands. Primary crops grown in the study area include sugarcane, soybeans, cotton, citrus, pecans, and truck crops. Both prime and unique farmlands occur in the area. Pastureland is also present. Although agricultural lands are of limited extent, they are important to the inhabitants of the area because they provide high quality fresh fruit and vegetables to the New Orleans SMSA.

ZOOLOGICAL

A.3.92. Wildlife. Because of the diversity and areal extent of productive habitat types, the study area supports a wide variety of wildlife including game species, commercially important furbearers and alligators, endangered species, and numerous nongame species that are ecologically important.

A.3.93. Migratory waterfowl are abundant in the marshes, bays, swamps, and seasonally flooded bottomland hardwood forests. The greatest concentrations of dabbling ducks are in the fresh to intermediate marshes and include mallards, gadwalls, wigeons, mottled ducks, green-winged teal, blue-winged teal, pintails, and shovelers. These species are generally less abundant in the more saline marshes. Diving ducks are most common in the bays, sounds, and larger marsh ponds and lakes. Lakes Pontchartrain and Maurepas winter an estimated 500,000 lesser scaup (Tarver and Dugas, 1973). Large concentrations of this species can also be found in Lake Borgne. According to Bellrose (1976), the coastal area between Mobile Bay and Louisiana winters an additional 17,000 lesser scaup. Bellrose also reported that the submerged grass beds of the Chandeleur Islands winter an estimated 20,000 redhead ducks annually. Ring-necked ducks are common in the fresh marshes and wooded swamps of the area. Other diving ducks include canvasbacks, red-breasted mergansers, hooded mergansers, greater scaup, buffleheads, oldsquaws, ruddy ducks, and common goldeneyes.

A.3.94. Waterfowl that nest in the area include mottled ducks, wood ducks, and possibly hooded mergansers. The mottled duck nests in the coastal marshes, primarily in the Pearl River delta and St. Bernard Parish marshes. Wood ducks commonly nest in the wooded swamps and seasonally flooded bottomland hardwood forests. Migrants from other regions also winter in these habitats.

A.3.95. Lesser snow geese are the only geese that winter in the area in significant numbers, primarily in the brackish marshes and sometimes on the barrier islands. Harvest records indicate that the dark color phase of this species, formerly called the blue goose, is more common in the area than the light phase.

A.3.96. King rail and clapper rail nest and winter in the coastal marshes while the Virginia rail and sora rail are winter residents. The American coot, a popular game bird with some waterfowl hunters, is primarily a winter resident of the fresh to brackish marshes. Scattered breeding of this species in the freshwater marshes of the area also occurs.

A.3.97. The common snipe winters in the fresh to brackish marshes and wet agricultural lands while the American woodcock occurs primarily in seasonally flooded bottomlands and fields. Resident mourning dove populations are present, but winter populations are much greater due to the influx of migrants from more northerly latitudes. Nesting occurs in a variety of habitats such as orchards, forest edges, fence rows, and riparian vegetation along small streams and drainage canals, church-yards, and other areas. Wintering dove populations feed heavily on agricultural lands supporting such crops as corn, rice, and soybeans. Some doves occur in association with the coastal marshes and forested wetlands. Bobwhite are primarily associated with areas where agricultural lands and forest edges are interspersed. The wild turkey is present in the bottomland hardwood and pine forests along the north shores of Lakes Pontchartrain and Maurepas, in portions of the Mississippi coastal plain, and in the Pearl River bottomlands and swamps. Hunters expended an estimated 149,700 man-days of hunting game birds in 1978.

A.3.98. Wading birds and seabirds are abundant in the area. Wading birds occur in the forested wetlands and marshes and on barrier islands. Seabirds are primarily associated with the brackish-to-saline open waters of the area but also range into the marshes and barrier islands for feeding and nesting. Common wading birds include great blue heron, yellow-crowned night heron, black-crowned night heron, great egret, cattle egret, snowy egret, reddish egret, white-faced ibis, and white ibis. Seabirds include the brown pelican, white pelican, ring-billed gull, herring gull, laughing gull, gull-billed tern, Forster's tern, common tern, black tern, least tern, sandwich tern, Caspian tern, royal tern, and black skimmer. The location of recently active seabird and wading bird nesting concentrations are shown in table 10 of the USFWS Final Planning Aid Report on this study published in June 1980. The marshes, barrier islands, and mainland beaches also provide habitat to numerous species of shorebirds such as black-necked stilt, American oystercatcher, killdeer, black-bellied plover, willet, greater yellowlegs, lesser yellowlegs, sanderlings, and various other small sandpipers. Other nongame marsh birds include the marsh hawk, long-billed marsh wren, belted kingfisher, red-winged blackbird, boat-tailed grackle, and seaside sparrow. The bottomland hardwood forests and wooded swamps support numerous nongame birds such as blue jay, cardinal, tufted titmouse, Mississippi kite, barred owl, warblers, vireos, wrens, kinglets, and woodpeckers.

A.3.99. The white-tailed deer, the primary big game mammal in the study area, is chiefly associated with the wooded swamps and bottomland hardwood forests. However, significant deer populations do occur in fresh to brackish marshes, especially when higher ground is located nearby.

A.3.100. Small game mammals include eastern cottontail, swamp rabbit, gray squirrel, fox squirrel, and raccoon. All of these species are pursued by sport hunters, who expend 339,000 man-days of hunting a year.

A.3.101. The eastern cottontail is most frequently found in association with pastures, row crop fields, fence rows, drainage ditches, and forest edges. Specimens have, however, been taken from the Chandeleur Islands (Lowery, 1974). The swamp rabbit is most commonly found in the wooded swamps, bottomland hardwood forests, and fresh to brackish marshes and has also been taken from the Chandeleur Islands.

A.3.102. Both gray and fox squirrels occur in the wooded swamps and bottomland hardwood forests. The fox squirrel also is found in the adjacent mixed pine hardwood forests that border the northern edges of the study area.

A.3.103. Commercially important furbearers include nutria, muskrat, mink, river otter, raccoon, striped skunk, bobcat, beaver, and opossum. Although nutria and muskrat are frequently present in seasonally flooded bottomland hardwood forests and wooded swamps, they are most abundant in the coastal marshes. Nutria reach peak populations in fresh marshes while muskrat are most abundant in brackish marshes where lush growths of three-cornered grass are present. Mink are most common in the forested wetlands. This species is also common in the coastal marshes, decreasing in abundance with increasing salinity levels. The river otter is found in association with forested wetlands, along streams, and in the coastal marshes. The raccoon is common throughout most wooded and marsh habitats and the barrier islands. The opossum, bobcat, and beaver are primarily associated with the bottomland hardwood forests and wooded swamps. Table A-3-10 shows fur catch and value by habitat type for coastal Louisiana. Table A-3-11 shows the estimated annual fur catch per 1,000 acres of coastal marsh by marsh type for muskrat, nutria, mink, raccoon, and river otter in the Louisiana coastal marshes. Similar figures are unavailable for the Mississippi Sound marshes.

A.3.130. The primary users of the recreational resources are residents of southeast Louisiana and southern Mississippi. The 1979-1980 survey conducted by the Louisiana Department of Culture, Recreation, and Tourism, Division of Outdoor Recreation, Office of Program Development, indicates that on a state wide average, 81.7 percent of boat fishing activity and 86.6 percent of the small game hunting activity occurs within 45 miles of the participant's residence. In Mississippi, existing data indicates similar user trends.

A.3.131. Recreational lands and facilities in the study area are categorized by use as private, public, or commercial. Commercial facilities serve the public on a fee basis. Public facilities include boat launching ramps, small marinas, and local parks and campgrounds. There are several Federal wildlife refuges in the area with a total of [illegible],333 acres, and several state wildlife management areas with a total of 211,045 acres. A summary of existing recreational facilities in the study area is shown in table A-3-13.

A.3.132. Although there is a great potential for recreation in the study area, several limiting factors have prevented coastal Louisiana's recreational potential from being fully realized. Access to many areas suitable for recreation is inadequate. The coastal Louisiana wetlands follow the shoreline and extend up to 90 miles inland making land access to recreation difficult and dictating access by water. The number of available boat ramps is not adequate to meet the demand of potential users. Many existing facilities are not developed to their full potential and are often concentrated in areas where road access is limited. Many coastal wetlands are privately owned and public use as well as access to other wetlands and shores is prohibited.

A.3.133. Other limiting factors that affect recreational use include the competition between commercial and recreational interests for the

boating and a winter base for waterfowl hunting and trapping. These camps are usually seasonally occupied and may be accessible only by water. Recreational fishing is by far the most significant and heavily pursued activity in the area. In the 1981-82 season, 119,992 resident sport fishing licenses were issued. The fact that most fishing is by boat is reflected in the 98,476 boat registrations issued in the study area during the 1981-82 period. Along the Louisiana-Mississippi coasts there are 600 species of fish associated with the estuarine or marine environment. To take advantage of fish clustering around the offshore oil platforms, 45 to 50 charter boats ferry saltwater anglers to these sites.

A.3.128. In Mississippi, saltwater fishing activities dominate other recreational activities such as freshwater fishing, boating, and water skiing. The Mississippi Sound attracts sport fish and the good saltwater fishing attracts sport fishermen. To take advantage of the excellent sport fishing available off the Mississippi coast, 36 charter boats are in business. These vessels are docked at Gulfport, Biloxi, Ocean Springs, and Gautier. Along the gulf coast, gigging flounder at night in shallow water along the beach is a favorite sport for those who visit the Mississippi beaches.

A.3.129. Hunting activities are as varied as fishing activities. Small game hunting is the most prevalent because a wider range of species and dependent habitat types are available. Big game hunting occurs only in the freshwater habitats and is not as intensive as in the more productive habitats such as bottomland hardwoods. Waterfowl hunting is the most well-known hunting activity in the area although the demand is lower than for other hunting activities. For the 1981-1982 hunting season, 81,222 resident small game licenses and 39,245 resident big game licenses were issued in the study area.

A.3.125. Another important shellfish resource is the Rangia clam, *Rangia cuneata*. Fossil deposits of the shells of this species as well as larger live specimens are harvested at a rate of 5 million cubic yards annually from Lakes Maurepas and Pontchartrain (Tarver and Dugas, 1973). Clam shells are used in the manufacture of concrete, glass, industrial chemicals, wallboard, and agricultural lime, in chicken and cattle feed, in road construction, to provide support for oil and gas exploration and production platforms, and as cultch material for oyster reef establishment.

RECREATION RESOURCES

A.3.126. Major recreational activities in the study area include fishing, hunting, boating, swimming, crabbing, shrimping, and camping. For millions of Louisiana residents and out-of-state tourists, the area is a focal point for recreational activities. The study area is blessed with numerous lakes, bayous, bays, swamps and marshes that provide an excellent environment for a wide range of recreational opportunities.

A.3.127. The estuarine environment supports an estimated 2,125,000 man-days of recreational activity worth 10 million annually. Louisiana's coastal marshes provide outdoor enthusiasts with year-round recreational opportunities. In the fall and winter season, hunters, trappers, and fishermen harvest ducks, muskrat, nutria, alligator, and numerous fresh and saltwater fish. Spring is the season to shrimp, crab, and fish for spotted seatrout, largemouth bass, and other finfish species. Because of limited access to the coastal area, most fishing is by boat. In areas that are close to urban centers and suitable for fishing, bank fishing usually occurs. Several recreational centers have evolved that fishermen use intentively including Chef Menteur, Little Woods, North Shore, and Spanish Fort. Thousands of camps have been constructed in the marsh to provide sportsmen with a summer site for fishing and

TABLE A-3-12

OYSTER REEFS WITHIN THE MISSISSIPPI SOUND
AND ADJACENT STUDY AREA

Location	Size (acres)	Reef approved for shellfish harvesting	Reef permanently closed
Dauphin Island Bay	9		X
Peavy Island	22	X	
Cedar Point	870 1/	X	
Heron Bay	145	X	
Middle Bay	5	X	
Point au Chenes	10	X	
Bangs Lake	20	X	
West Pascagoula Bay	540		X
Graveline Bayou	5		X
Deer Island	4		X
Ocean Springs	180		X
Biloxi Bay	350		X
Pass Christian	7,680	X	
St. Louis Bay	250		X
Point St. Joe	740	X	
TOTAL	10,830		
Long Beach Tonging 2/ Reef			3/
Waveland Tonging 2/ Reef			3/
St. Stanislas 2/ Tonging Reef			3/

Source: Gulf Coast Research Lab (1973) Mississippi Sound and Adjacent Areas Dredged Material Disposal Study (Stage 1) Reconnaissance Reports, Appendix A, Resource Inventory, March 1979.

1/ Over half of the reef is within Mobile Bay with an additional 870 acres occuring within Mississippi Sound.

2/ Deegan, personal communication

3/ Being established

the junction of Mississippi Sound and Mobile Bay. The bayous that empty into the sound also support the growth of oysters.

A.3.123. Until the mid-1900's, natural reefs supplied an abundance of oysters for Mississippi. However, pollution and siltation resulting from man's activities and overharvesting led to poor, fluctuating catches during the 1940's and 1950's. Active management of oyster resources has increased the reliability of the fisheries. The Mississippi Marine Commission reports that between 1880 and 1940 the average oyster production for the Mississippi Sound was 4,117,108 pounds. However, as a result of oyster overharvesting, pollution, and the widespread damage caused by the oyster drill, production dropped to an average of 633,908 pounds between 1941 and 1959. In 1960, the State of Mississippi began actively managing the oyster resource. As a result, the annual landings for 1960 to 1969 averaged 2,731,157 pounds. In 1969 Hurricane Camille destroyed many of the oysters and oyster landings dropped to 415,000 pounds in 1970. Oyster harvesting is steadily increasing, however, as indicated by a harvest of 1,386,000 pounds in 1977 (May, 1971).

A.3.124. Due to the lack of suitable water bottoms, only a small percentage of oyster-producing areas are leased in Mississippi. The Mississippi Department of Conservation has issued about 40 leases; however, only about five or six leases are currently active. Individuals are presently attempting to develop oyster beds within Mississippi Sound. However, this is a recent practice on the private reefs so present production is very small compared to oysters harvested on public reefs. Information on oyster reefs in the sound is presented in table A-3-12.

second in total poundage for that period with average annual reported landings of over 27.9 million pounds. Shrimp led all species in value of catch, worth nearly $31.0 million (dockside) annually for the period. Other species in order of decreasing economic importance by total value of inshore landings include menhaden, American oyster, blue crab, spotted seatrout, and red drum. Offshore commercial landings for the Chandeleur and Mississippi Sound areas are believed to depend heavily on the nursery grounds in the study area for their production.

A.3.121. The oyster is the only commercially important edible mollusk in the study area. In Louisiana, oyster-producing areas are divided into private leases harvested by individual oyster fishermen and oyster seed reefs that are available to the public. Private leases in the study area total about 51,000 acres. Because favorable salinity levels are decreasing, only an estimated 20 percent of these leases are productive. There are approximately 250,000 acres of public oyster seed grounds located along the fringes of the St. Bernard marshes. Of the 250,000 acres, only an estimated 12,000 acres have suitable substrate for oyster production. The approximate locations of public oyster reefs and private oyster leases are shown in plate A-6. In recent years, oyster production has decreased 60 to 80 percent in this area as a result of increased salinity. Seed grounds are the limiting factor in oyster production in Louisiana. About 70 to 80 percent of all oysters produced in Louisiana have their origin on the state seed grounds. Oyster fishermen usually enter the seed grounds during September, October, and November to dredge for the small seed oysters (1 to 3 inches in diameter). The seed oysters are then transferred to leased water bottoms until they grow to a size suitable for market.

A.3.122. Approximately 10,830 acres of established oyster reefs are within the Mississippi Sound. The largest reefs are in the western portion of the sound near Pass Christian and in the eastern portion at

A.3.118. Freshwater sport fishing is generally limited to the fresh-to-slightly-brackish reaches of coastal rivers, and to freshwater lakes and ponds. Primary species harvested include largemouth bass, spotted bass, yellow bass, black crappie, white crappie, bluegill, spotted sunfish, redear sunfish, warmouth, channel catfish, flathead catfish, and blue catfish. Important commercial fishes include blue catfish, channel catfish, flathead catfish, yellow bullhead, bowfin, carp, gars, and buffaloes.

A.3.119. According to the "1975 National Survey of Hunting, Fishing, and Wildlife-Associated Recreation" (National Analysts, Undated), approximately 192,000 persons spent nearly 5.4 million days participating in saltwater fishing in Mississippi in 1975. That survey also indicated that surf and shore fishing for saltwater species was most popular followed by pier, jetty, and bridge fishing, deep sea fishing, fishing in bays, sounds, and coast areas by boat, and fishing in brackish rivers, streams, and marshes. However, the standard error of the sample used to estimate the above distribution was sufficient to question the utility of these findings. The magnitude of saltwater fishing in Mississippi in 1975 was estimated by the Mississippi Park Commission (1977) at 3.78 million man-days. An analysis of saltwater angling in Biloxi Bay was conducted by McIlwain (1978) during the period May 1972 through February 1974. This analysis revealed that 96,175 fishermen harvested 704,934 pounds of fish during the study period. The most important species taken in terms of total poundage were spotted seatrout, Atlantic croaker, sand seatrout, and sea catfish.

A.3.120. Estuarine and marine commercial fishery resources are also of great economic importance to the study area. Menhaden dominate the commercial inshore harvest with an average annual reported harvest of 51.8 million pounds recorded for the period of 1963-78. Shrimp rank

moderate salinity portions of the area only as nursery areas during their early life stages and move to more saline waters as they mature.

A.3.116. Sport fishing in the area is significant and diverse. The area supports approximately 1,822,800 man-days of fresh and salt water boat-fishing. Several generalizations can be made from prior observations and surveys. Much bank fishing occurs along jetties, seawalls, bulkheads, bridges, breakwaters, piers, and canal and bayou banks in the Lake Pontchartrain area, especially along the south shore of the lake in the New Orleans area. Fishing from small to medium-sized boats, primarily outboard powered, is common in the numerous bays, canals, bayous, and other relatively shallow inland waters of the St. Bernard sub-delta and the Pearl River delta. The numerous low-crest weirs across tidal watercourses on the Biloxi Wildlife Management Area serve to attract sportfishes and facilitate harvest by anglers. Sport fishes are also frequently taken in large numbers in and near large tidal passes such as Chef Menteur Pass and the Rigolets, and near the IHNC at Lake Pontchartrain in New Orleans. Offshore oil and gas production platforms also attract large numbers of fish such as spotted seatrout, Atlantic croaker, sand seatrout, king mackerel, Spanish mackerel, cobia, bluefish, greater amberjack, spadefish, and red snapper. Anglers heavily fish many of these rigs. Oyster reefs also attract numerous sport fishes such as red drum, Atlantic croaker, spotted seatrout, black drum, and sheepshead. Several artificial reefs have been established in Mississippi Sound in an effort to provide increased sport fishing opportunities.

A.3.117. The surf zone and seagrass beds associated with the Chandeleur Islands and the barrier islands bordering Mississippi Sound also provide quality sport fishing. Species commonly taken include red drum, spotted seatrout, sand seatrout, gulf kingfish, southern flounder, and Spanish mackerel.

equine encephalitis, California encephalitis, and Venezuelan equine encephalitis. The various strains of viral encephalitis are periodically found in native wildlife populations that serve as reservoirs for viral inoculum. Increased mosquito population densities could enhance the rate of disease transmission if local outbreaks occur.

A.3.114. Fisheries. The diversity of fresh to saline aquatic habitat supports a wide range of finfish and shellfish resources. The fishery resources include freshwater species that primarily use the fresh and intermediate areas, and marine species that primarily use the brackish and saline areas. Many marine species also use the lower salinity areas as nursery habitat during their juvenile stage of development. The majority of the important finfish and shellfish species are estuarine-dependent, using the estuarine areas during certain periods of their life cycle. These species generally spawn offshore in high salinity, temperature stable waters. For most species, spawning is protracted but each species has peak spawning periods. After the eggs hatch, the organisms pass through a series of larval stages. The larval and postlarval stages migrate into the fertile lower-salinity estuarine areas under the influence of tides and currents. The juveniles grow very rapidly during the spring and summer months, taking advantage of warmer temperatures, protection from predators, and the rich detrital food chain. The organisms generally begin to migrate offshore with the onset of cooler weather.

A.3.115. The sport and commercial fishery resources of the study area are primarily estuarine/marine and are of great economic and recreational importance. Because of the large quantity of tidal marshes, submerged grass beds, and shallow estuarine waters, this region provides prime habitat for a variety of estuarine finfish and shellfish. Some of the species involved, such as the American oyster, are year-round residents. However, many species utilize the low-to-

A.3.112. The American alligator remains on the US Department of the Interior's list of endangered species in Mississippi and Alabama. However, alligators found in the Louisiana portion of the study area are now classified as "threatened" under the Similarity of Appearance clause of the Endangered Species Act of 1973 (Federal Register, June 25, 1979). This reclassification allows for controlled alligator hunting. In 1980, harvest of alligators in Louisiana was valued at approximately $2 million. Potential harvest in the Louisiana portion of the study area is 1,023 alligators. The annual net value of these alligators is approximately $157,000 for their meat and hides.

A.3.113. Terrestrial invertebrates are numerous and diverse throughout the study area. A variety of insects and other arthropods, land snails, nematodes and other worms, and terrestrial protozoans abound and are important constituents of the terrestrial food web. Insects are the most notable for their vector potential. Vectors are species that transmit disease organisms that affect higher animals, including man, or that affect man's comfort, mental composure, and economic welfare. Mosquitoes are the most important of these insects in the area although other groups, such as deerflies, horseflies, and biting midges are also considered vectors. Habitat alteration by such activities as disposal of hydraulically dredged material has the potential to increase the breeding habitat for such species as *Aedes sollicitans* (the salt-marsh mosquito) and *Culex salinarius*. The former requires temporary water areas while the latter requires permanent water bodies. *Aedes sollicitans* normally breeds along the periphery of swamps and marshes that, along with fluctuating water levels, provide habitat suitable for egg and larval development. Suitable habitat also occurs in partially dewatered areas with cracked surfaces. As the areas dry out, the adult mosquitoes lay their eggs in the cracks. Rainwater and water temperatures provide the necessary stimuli for hatching. *Aedes sollicitans* is a known vector for eastern equine encephalitis, western

arctic peregrine falcon, red cockaded woodpecker, and Mississippi sandhill crane. The bald eagle is found in the marshes, lakes, and swamps from early fall to late spring. Recently active nests have been confirmed near White Kitchen in St. Tammany Parish, Louisiana. The brown pelican feeds in the shallow waters adjacent to the barrier islands. Recent attempts to reestablish a nesting colony of this species on the Chandeleur Islands have met with limited success. The arctic peregrine falcon is an occasional visitor to the area marshes and barrier islands. The red cockaded woodpecker is found in mature pine stands of adjacent uplands.

A.3.109. The entire population of the Mississippi sandhill cranes is limited to 40 to 50 individuals located in the coastal savannas of Jackson County, Mississippi. Much of the critical habitat used by these birds is now protected as part of the Mississippi Sandhill Crane National Wildlife Refuge established in 1974.

A.3.110. Other endangered birds of doubtful occurrence include Bachman's warbler, Eskimo curlew, and ivory-billed woodpecker. None of these species have been confirmed in the study area in recent years. The only endangered land mammal that may occur in the forested bottomlands and wooded swamps is the Florida panther. Although recent sightings have been reported in both the Louisiana and Mississippi portions of the study area, few, if any, have been confirmed.

A.3.111. Endangered marine mammals that may occur in the waters of the study area include the blue whale, finback whale, humpback whale, sei whale, and sperm whale. A West Indian manatee was recently captured in the Gulfport Small Craft Harbor at Gulfport, Mississippi, and relocated to Florida by the USFWS.

A.3.104. Nongame mammals are also numerous in the area. The rice rat is common in the marshes. Typical nongame mammals in the forested portions of the area include eastern wood rat, white-footed mouse, short-tailed shrew, and nine-banded armadillo. The Atlantic bottlenose dolphin is the most common marine mammal in the open waters of the study area, found primarily in the bays, sounds, and tidal passes.

A.3.105. Amphibians are generally restricted to the freshwater marshes, ponds, stream and lake margins, and forested wetlands of the study area. The bullfrog and pig frog are important from a commercial and sporting standpoint. Other representative amphibians include lesser siren, gulf coast toad, oak toad, Fowler's toad, green treefog, cricket frog, and bronze frog.

A.3.106. Commercially-important reptiles in the marshes and swamps include the American alligator, common snapping turtle, alligator snapping turtle, smooth softshell turtle, spiny softshell turtle, and diamondback terrapin. Other reptiles common in these habitats include red-eared turtle, stinkpot, green anole, broadheaded skink, diamondback water snake, banded water snake, gulf salt marsh snake, and western cottonmouth. Of these, only the gulf salt marsh snake and diamondback terrapin are common in the brackish to saline marshes.

A.3.107. Sea turtles occur in the saline waters in or adjacent to the project area and include the threatened loggerhead and green sea turtles. The endangered ridley, hawksbill, and leatherback sea turtles are also found in or adjacent to the area. The Atlantic loggerhead is reported to nest on the Chandeleur Islands (Burk and Associates, Inc., Undated).

A.3.108. Several other endangered species are found in the area. Endangered birds known to occur include the bald eagle, brown pelican,

TABLE A-3-11

ESTIMATED FUR CATCH PER 1,000 ACRES OF LOUISIANA COASTAL MARSH[1/]

	Saline		Brackish		Intermediate		Fresh	
	Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum
Muskrat	2/	2/	84.4	6,477.7	97.5	513.9	78.5	646.8
Nutria	2/	2/	86.4	191.1	284.9	499.6	512.7	884.4
Mink	2/	2/	1.1	12.8	0.9	11.0	2.1	14.2
Raccoon	2/	2/	2/	15.6	2/	6.3	2/	31.0
Otter	2/	2/	0.2	0.7	0.4	1.3	0.5	1.3

1/ From Palmisano (1973).

2/ Inadequate records.

TABLE A-3-10

FUR CATCH AND VALUE BY HABITAT TYPE FOR COASTAL LOUISIANA

Species	Fresh-Intermediate Marsh	Habitat Type Brackish Marsh	Saline Marsh	Wooded Swamp
<u>Muskrat</u>				
Average catch/acre[1]	0.0880[2]	0.0844	0.0169[3]	0.0273[4]
Value/pelt[5]	$5.43	$5.43	$5.43	$5.43
Value/acre	$0.4778	$0.4583	$0.0918	$0.1482
<u>Nutria</u>				
Average catch/acre	0.3988[2]	0.0864	insignificant	0.1995[4]
Value/pelt	$7.39	$7.39	-	$7.39
Value/acre	$2.9471	$0.6385	insignificant	$1.4743
<u>Mink</u>				
Average catch/acre	0.0015[2]	0.0011	insignificant	0.0216[4]
Value/pelt	$13.67	$13.67	-	$13.67
Value/acre	$0.0205	$0.0150	insignificant	$0.2953
<u>Otter</u>				
Average catch/acre	0.0005[2]	0.0002	insignificant	0.0005[4]
Value/pelt	$44.55	$44.55	-	$44.55
Value/acre	$0.0223	$0.0089	insignificant	$0.0223
<u>Raccoon</u>				
Average catch/acre	0.0093[6]	0.0078[7]	insignificant	0.0984[8]
Value/pelt	$11.46	$11.46	-	$11.46
Value/acre	$0.1066	$0.0894	insignificant	$1.1277
<u>Total</u>				
Average catch/acre	0.4979	0.1799	0.0169	0.3473
Gross value/acre	$3.5743	$1.2101	$0.0918	$3.0678
Net value/acre[9]	$2.6807	$0.9076	$0.0689	$2.3009

1/ Average catch per acre, unless otherwise noted, from Palmisano (1973).

2/ Represents mean of fresh and intermediate marsh average harvest/acre reported by Palmisano (1973).

3/ Calculated as 25 percent of brackish marsh average harvest/acre reported by Palmisano (1973).

4/ Calculated as a percentage of fresh marsh average harvest/acre reported by Palmisano (1973), based on a comparison of the two habitat types by Nichols and Chabreck (1973).

5/ Based on 1976-81 running average of prices received by the trapper, expressed in 1981 dollars using the *Consumer Price Index* for hides, skins, leather and related products. Base price data compiled by Louisiana Department of Wildlife and Fisheries.

6/ Represents one-half of the combined maximum production for fresh and intermediate marsh types reported by Palmisano (1973).

7/ Represents one half the maximum value reported by Palmisano (1973).

8/ Based on harvest projected by Nichols and Chabreck (1973).

9/ Cost of harvest equals 25 percent of gross value; net value equals gross value minus cost of harvest.

TABLE A-3-13

EXISTING OUTDOOR RECREATIONAL FACILITIES INVENTORY

Proprietorship	Boat Launching Lanes	Other Amenities
Federal	4	78,550 acres, 10.5 miles of trails, picnicking, camping, fishing
State	28	104,320 acres, trails, hunting, camping, fishing, seashore recreation, picnicking
Parish	52	Fishing, camping, picnicking, boating, waterskiing, scenic vistas
County	2	Small craft harbors
Local	60	Fishing, marina
Commercial	52	Restaurants, fishing, camping, picnicking, trails, swimming, boat hoists
Total	198	

same resources. Since land access is limited by the physical environment, areas that could be used for recreation must vie with industrial and residential uses. The competition often results in congested strip development that aggravates the problem of accessibility for recreationists.

CULTURAL RESOURCES

A.3.134. The study area has a rich cultural heritage, a result of the diversity and abundance of natural resources and the strategic importance of Mississippi River trade and commerce. Historical settlement on the Mississippi Gulf Coast and the Mississippi River banks has been intensive since the early 1700's.

A.3.135. Numerous archeological sites have been identified. The sites include early settlements, prehistoric earth and shell middens, forts, historic shipwrecks, and structures. These resources date back to the earliest exploration and settlement and represent the various stages in the area's history.

A.3.136. The National Register of Historic Places as published in Federal Registers dated 6 February 1977 and annual and weekly supplements through 17 May 1983 was consulted and the historic properties noted. In the Louisiana portion of the study area, 18 properties have been listed in the Register. However, eight of these properties are located on the Mississippi River's natural levee and are outside of the affected project area.

A.3.137. There are 25 properties listed in the three Mississippi counties which comprise the Mississippi portion of the study area.

A.3.138. Over 290 recorded archeological sites are located in the Louisiana portion of the study area. In addition, 255 archeological sites are recorded in Hancock, Harrison, and Jackson Counties of Mississippi. The most common archeological sites are earth and shell middens. Middens are concentrations of various types of refuse built up over a period of years. They represent the garbage of the prehistoric occupants of the site, and thus provide information on subsistence, diet, and technology. The predominant components of these middens are the shells of two species of shellfish: oyster and Rangia cuneata.

Section 4. FUTURE CONDITIONS

A.4.1. The most probable future conditions if no Federal action is taken are determined by projecting conditions that will prevail in the area over the planning period 1980 to 2040. The conditions described are based on available information.

HUMAN RESOURCES AND ECONOMY

A.4.2. Population in the study area is expected to increase from 1,767,540 in 1980 to 2,676,300 in 2040. The population projections are shown in table A-4-1. The classic pattern of regional urbanization is expected to continue with the population concentrating around the large urban areas. As the trend continues through the projection period, the parishes and areas adjacent to urban areas will become more densely settled. The only foreseeable constraint on this trend would be if the developable lands are exhausted.

A.4.3. The New Orleans SMSA will maintain a significant share of the study area population in the future. The SMSA is expected to account for 65 percent of the total population. In the Louisiana portion of the study area, St. Charles Parish is expected to experience the largest growth (67 percent), while St. John the Baptist Parish will grow by 61 percent. The growth is directly associated with improved transportation facilities between New Orleans and the outer parishes and lower land prices in the parishes. In Mississippi, Harrison and Hancock Counties are expected to have a combined population increase of 52 percent. These counties account for 10.3 percent of the study area population and this share is expected to remain constant through the study period. In the Mississippi portion of the study area the population in 1980 was 300,217 and is expected to increase to 522,500 by 2040.

TABLE A-4-1

POPULATION PROJECTIONS

	1980	1985	1990	2000	2010	2020	2030	2040
Mississippi								
Biloxi-Gulfport SMSA 1/	191,918	200,900	210,500	228,400	242,900	258,400	274,800	292,300
Hancock County	24,537	190,700	199,800	216,800	230,500	245,200	260,800	277,400
Harrison County	157,665							
Pascagoula-Moss Point SMSA 1/ (coextensive with Jackson County)	118,015	141,400	156,800	180,100	194,500	210,100	226,900	245,100
Mississippi Portion of the Study Area	300,217	332,100	356,600	396,900	425,000	455,300	487,700	522,500
Louisiana								
Baton Rouge SMSA	494,151	502,000	536,500	584,800	619,300	655,800	[illegible]	735,500
Ascension Parish	50,068	110,400	118,000	128,700	136,200	144,300	152,800	161,800
Livingston Parish	58,806							
New Orleans SMSA 1/	1,187,073	1,212,200	1,275,500	1,377,000	1,457,900	1,543,600	1,634,400	[illegible]
Jefferson Parish	454,592	-	-	-	-	-	-	-
Orleans Parish	557,515	-	-	-	-	-	-	-
St. Bernard Parish	64,097	-	-	-	-	-	-	-
St. Tammany Parish	110,869	-	-	-	-	-	-	-
Non-SMSA Parishes								
St. Charles Parish	37,259	39,000	41,900	47,000	51,000	54,500	58,300	62,100
St. James Parish	21,495	22,000	22,500	23,500	24,000	24,500	25,500	26,500
St. John the Baptist Parish	31,924	33,000	35,400	39,500	42,500	45,500	48,500	51,500
Tangipahoa Parish	80,698	81,600	88,800	96,600	102,300	108,300	114,700	121,400
Louisiana Portion of the Study Area	1,467,323	1,498,200	1,582,100	1,712,300	1,813,900	1,920,700	2,033,900	2,153,800
Total Study Area 2/	1,767,540	1,830,300	1,938,700	2,109,200	2,238,900	2,376,000	2,521,600	2,676,300

Source: US Dept. of Commerce, Bureau of Economic Analysis, 1980 OBERS BEA Regional Projections, July 1981; and Bureau of the Census, Census of Population, "Number of Inhabitants", 1982. Projections of County and Parish data reflect disaggregati[illegible], and analysis by the [illegible] Orleans District.

1/ SMSA: Standard Metropolitan Statistical Area. The Biloxi-Gulfport SMSA also includes Stone County, determined not within the impacted area. The Baton Rouge SMSA also includes East Baton Rouge and West Baton Rouge Parishes, determined not within the impacted area and not included within the Study Area.

2/ The Total Study Area includes only the 10 parishes and three counties, and not entire SMSA's.

A.4.4. Per capita income in the area is expected to increase during the study period. In 2040, New Orleans SMSA is estimated to have the highest per capita income of $21,800. The next highest per capita income is expected to occur in the Baton Rouge SMSA and Jackson County, $21,700 and $18,500, respectively. The national per capita income is expected to increase from $5,227 in 1978 to $18,100 in 2040. Per capita income projections are shown in table A-4-2.

A.4.5. Economic growth in the area is primarily due to the availability of natural resources: oil and gas, waterways for transportation, commercial fisheries and wildlife, climate, and water-oriented recreation activities. Projected employment is shown in table A-4-3. Assuming only minor changes in the current industrial employment trends, increases in services, trade, and manufacturing in the New Orleans area are projected while mineral production employment would decline. A similar pattern is projected for the Biloxi-Gulfport area. Marine construction and other manufacturing industries are projected to remain a primary source of employment in the Pascagoula-Moss Point area. The manufacture of durable goods is expected to account for about one-half of total employment in that area by the year 2040.

A.4.6. Over the period 1940-1980, the number of part-time commercial fishermen increased fairly steadily. In view of the projected decline in marsh productivity, there is little evidence to suggest any significant growth in the number of persons able to earn their entire living as commercial fishermen. So-called part-time fishermen may well increase in number due to reclassification of former fulltime fishermen. However, the dwindling resource base leads to the conclusion that the total man-hours spent in commercial fishing will decline.

TABLE A-4-2

PER CAPITA INCOME IN 1972 DOLLARS

	1978	1980	1990	2000	2010	2020	2030	2040
Mississippi	3,721	4,763	5,569	7,291	9,287	11,236	13,800	17,100
Biloxi-Gulfport SMSA	4,009	5,074	5,911	7,688	-	-	14,495	17,900
Pascagoula-Moss Point SMSA	4,102	6,378	6,262	8,325	-	-	15,952	18,500
Louisiana	4,492	5,719	6,630	8,534	10,700	12,802	15,642	18,900
Baton Rouge SMSA	5,017	6,295	7,300	9,437	-	-	17,476	21,700
New Orleans SMSA	5,099	6,434	7,451	9,588	-	-	17,599	21,800
Non-SMSA Part of BEA Economic Area 113: New Orleans, (LA Part)	4,281	5,486	6,361	8,181	-	-	14,934	17,200

Source: US Dept. of Commerce, Bureau of Economic Analysis, 1980 OBERS BEA Regional Projections, Vol. 8.

TABLE A-4-3

EMPLOYMENT PROJECTIONS

	1978	1980	1990	2000	2010	2020	2030	2040
Mississippi	1,008,223	1,162,652	1,268,137	1,444,996	1,588,913	1,649,901	1,702,684	1,756,000
Biloxi-Gulfport SMSA	81,494	92,100	99,299	111,507	-	-	129,484	132,000
Pascagoula-Moss Point SMSA	54,759	71,189	81,266	96,609	-	-	117,435	121,000
Louisiana	1,698,995	2,005,688	2,175,685	2,427,676	2,636,676	2,716,013	2,789,098	2,844,000
Baton Rouge SMSA	200,087	245,776	269,708	303,738	-	-	351,263	362,000
New Orleans SMSA	546,209	631,403	682,171	760,796	-	-	879,435	922,000
Non-SMSA Part of BEA Economic Area 113: New Orleans, (LA Part)	163,0[illegible]6	198,881	217,198	243,209	-	-	272,807	287,000

Source: US Department of Commerce, Bureau of Economic Analysis, 1980 OBERS BEA Regional Projections, Vol. 8.

LAND RESOURCES

A.4.7. Historical trends affecting the land resources are expected to continue and result in further reducing the areal extent and diversity of the resources by the year 2040. Primary forces shaping the land are the natural processes of erosion, subsidence, and a general rise in sea level, and man's activities.

A.4.8. The land loss rate in the Louisiana portion of the study area is projected to be 2.5 acres per year. In the Mississippi portion, the land loss rate is projected to be less than 1 acre per year. A more detailed discussion of the projected land loss and conversion are contained in Appendix D, Natural Resources.

A.4.9. The shoreline erosion rates for Lakes Maurepas, Pontchartrain, and Borgne shown in table A-4-4 are projected to continue in the future. The Chandeleur Island chain will continue to erode and shift landward. For these islands, Morgan and Larimore (1957) estimated a retreat ratio of 13.7 feet per year between 1932 to 1954. Adam et al. indicated the rate accelerated to 22.6 feet per year for the period 1954 to 1967. This rate is expected to further increase in the future throughout the study area. Other forces such as subsidence, a general rise in sea level, and canal dredging, are expected to continue contributing to the loss of the land resources.

TABLE A-4-4

EROSION RATES FOR LAKES MAUREPAS, PONTCHARTRAIN, AND BORGNE

Lake	Mean Erosion rate (m/yr/km) 1930's - 1950's	1950's - 1970's
Maurepas	0.6	0.8
Pontchartrain 1/	1.6	2.3
Borgne 2/	1.5	2.0

Source: Special Report: A Plan of Study for Freshwater and Sediment Diversion in Coastal Louisiana, Department of Transportation and Development, Office of Public Works, April 1980.

1/ Includes only those shorelines that do not contain structures designed to reduce erosion.

2/ From Chef Menteur Pass to Rigolets

A.4.10. The activities of urbanization and industrialization are expected to affect the wetlands. Several residential developments similar to Eden Isles and Venetian Isles have been proposed along the northeast shore of Lake Pontchartrain in St. Tammany Parish (Plate A-11). Such development would contribute to wetland losses. A portion of the wetlands in Orleans Parish will probably be drained for urban development. Future urban pressure may cause the development of wetlands along the south shore of Lake Pontchartrain in St. Charles Parish. In St. Bernard Parish, wetlands adjacent to the Mississippi River natural levees and Highway 46 may be drained for future development. In Mississippi, the population increase along the gulf coast will cause additional burden to the lands. Future development will contribute to the erosion and land loss of the Mississippi Gulf Coast.

A.4.11. Most of the projected land loss and conversion would occur to wetlands. This land resource change is expected to have substantial adverse impacts on the quantity and quality of the fish and wildlife resources in the area. The continual loss of the land resources would also affect most facets of development in the area.

WATER RESOURCES

A.4.12. Water quality will be affected by changes in the population and by industrial activities expected to increase significantly in the area. Advances in industrial materials recovery processes and continued application of discharge permit restrictions and processes should encourage industries to discharge generally cleaner effluents. Wastewater discharges from municipalities, industries, and vessels are expected to markedly increase.

A.4.13. The State of Louisiana has intensified discharge permit monitoring and enforcement efforts. The efforts will probably slow the degradation of existing water quality. Despite the recently initiated state effort, current economic pressures may force Federal agencies to be less aggressive in meeting the objectives of the Federal Water Pollution Control Act of 1972. Therefore, substantial improvements in the overall quality of study area waters is not anticipated in the foreseeable future.

A.4.14. The water surface area is anticipated to continue to increase in the future. This change is due to erosion and subsidence of land and a general rise in sea level.

BIOLOGICAL RESOURCES

A.4.15. Habitat deterioration is expected to continue in the study area. As a result of these changes, the marsh is expected to experience a loss of about 91,000 acres by the year 2040, a 28 percent reduction in total marsh acreage. Bottomland hardwoods in the area would be reduced from 90,782 to 74,052 acres by 2040, a loss of 18 percent. This loss would be due primarily to clearing and development. Wooded swamp would be reduced by 46 percent or 86,182 acres. Some wooded swamp would be drained and used for other purposes and some would be killed by saltwater intrusion. Tables A-4-5 and A-4-6 present the anticipated changes in habitat types for future without project conditions.

A.4.16. The loss and alteration of habitat types would adversely affect productivity of both wildlife and fishery resources. Because of the relationship between total marsh acreage and fishery production, there would be substantial declines in populations of finfish and shellfish.

A.4.17. Construction of the MR-GO resulted in dramatic increases in salinity and changes in the wetlands in St. Bernard Parish near Lake Borgne. About 9,705 acres of fresh marsh and wooded swamp have been converted to brackish marsh and 6,250 acres of brackish marsh converted to saline marsh (Coastal Environments, 1982). These changes have made the area much less valuable to waterfowl and furbearers and the increased salinities have had a dramatic effect on the oyster fishery. Prior to 1960, the St. Bernard marsh was the most productive oyster harvesting area in the state, accounting for 70-75 percent of the oysters harvested in Louisiana. By 1970 the productive oyster zone shifted completely into Lake Borgne due to saltwater intrusion from the MR-GO. The zone is closer to sources of domestic pollution and the ar is subject to periodic closures by health officials. Oyster beds are now appearing in Lake Pontchartrain. However, because of pollution

TABLE A-4-5

COMPARISON OF HABITAT TYPES WITHOUT PROJECT-MISSISSIPPI

(Acres)

	1978	1990	2000	2010	2020	2030	2040
Bottomland Hardwoods	42,394	41,637	41,017	40,406	39,804	39,210	38,626
Wooded Swamp 1/	33,162	33,162	33,162	33,162	33,162	33,162	33,162
Fresh Intermediate Marsh	19,885	18,575	17,633	16,802	16,061	15,397	14,795
Brackish Marsh	19,942	19,515	19,167	18,825	18,489	18,159	18,834
Saline Marsh	27,325	26,580	25,975	25,384	24,086	24,241	23,690
Total Marsh	67,152	64,670	62,775	61,011	59,356	57,797	56,319

1/ Loss rate negligible.

TABLE A-4-6

COMPARISON OF HABITAT TYPES WITHOUT PROJECT-LOUISIANA

(Acres)

	1978	1990	2000	2010	2020	2030	2040
Bottomland Hardwoods	48,338	45,516	43,291	41,174	39,161	37,247	35,426
Wooded Swamp	155,507	133,071	116,868	102,638	90,140	79,164	69,525
Fresh/Intermediate Marsh	58,346	54,282	51,111	48,126	45,315	42,668	40,177
Brackish Marsh	137,662	129,626	123,288	117,261	111,528	106,075	100,889
Saline Marsh	56,386	50,223	45,604	41,411	37,605	34,145	31,005
Total Marsh	252,394	234,131	220,003	206,798	194,446	182,888	172,071

these beds are closed to harvesting. The St. Bernard area only contributes about 20 percent of the oysters harvested in Louisiana. In Louisiana and Mississippi, the historically productive reefs which flourished before the construction of the Mississippi River levees will continue to lie dormant and the lesser production which now occurs more inland will be plagued by man's pollution problems. The effect of leveeing of the Mississippi River on oyster reefs in Mississippi and Louisiana has been reviewed by Gunter (1952, 1953, 1975). The Mississippi oyster industry was at its prime between 1880 and 1940 when the Mississippi River had low levees or none south of New Orleans. The seasonal flooding of the river lowered salinities over the oyster reefs and provided great quantities of nutrients. However, due to the levees which now exist, river water does not flow over the reefs and the original oyster zones in Mississippi and Louisiana are significantly smaller. These historic reefs are quite impressive in size. Gunter and Demoran (1970) stated that these reefs lie on 21-foot deposits of shells about 7,000 years old at the bottom. Demoran (1966) states that the Pass Christian reefs constitute one of the largest nearly continuous oyter reefs in the world. In the early part of this century, Biloxi, Mississippi was second only to Baltimore, Maryland, as the largest oyster processing city in the United States (Churchhill, 1920).

A.4.18. Wildlife productivity would decline due to direct loss of habitat. Fresh/intermediate marsh areas provide more favorable habitat for furbearers, waterfowl, and the American alligator. As a result of direct habitat loss, the average annual harvest of furbearers would be reduced. Land loss would also damage Louisiana's revived commercial alligator industry, valued at approximately $2 million in 1980.

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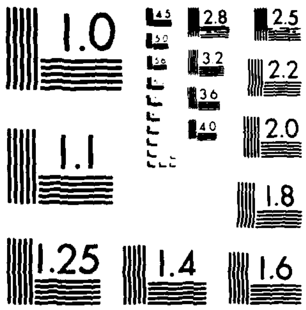
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RECREATION RESOURCES

A.4.19. Recreation demands are expected to significantly increase in the future. Hunting needs are estimated to increase from 4,128,800 man-days in 1980 to 6,729,900 man-days by 2040. The need for boat launching lanes is expected to increase from 1,160 lanes in 1980 to 1,862 lanes by 2040. Population growth and associated industrial development will increase the competition between commercial and recreation interests for the same resources.

A.4.20. The continued loss of productive marsh fish and wildlife habitat will adversely affect future opportunities for fishing and hunting. The opportunities for hunting will decrease proportionally with the loss of marsh. While fishing will not be subjected to a shrinking resource base, the activity will suffer qualitatively as the marsh types on which fishing productivity depends are destroyed. This loss to fishing and hunting is valued at approximately $1,000,000 annually.

CULTURAL RESOURCES

A.4.21. In the future, the destructive forces of erosion, wavewash, saltwater intrusion, and subsidence will continue to destroy cultural resources in the marshes. Cultural resources located in the study area and especially along the natural levees of the river will continue to be adversely affected by urban and industrial development.

Section 5. PROBLEMS, NEEDS, AND OPPORTUNITIES

HUMAN RESOURCES AND ECONOMY

A.5.1. Population growth in the study area will put additional stress on the environment. Increases in population will require more land for urbanization and industrialization and will cause forests, agricultural lands, and marshes to be converted to urban, surburban, and industrial uses. Much of the converted land will be adjacent to the natural levees of the Mississippi River, along the shores of Lake Pontchartrain, and along the abandoned tributary system in St. Bernard Parish. Urban development along the shores of Lakes Pontchartrain and Maurepas will result in destruction of tidal marshes vital to fish and wildlife productivity. Virtually all tidal streams and fringing wetlands along the southeastern shore of Lake Pontchartrain have already been divorced from the lake as a result of land reclamation and urbanization.

A.5.2. In Mississippi, population growth will be concentrated along the Mississippi Gulf Coast. Urbanization and industrialization will adversely affect water bodies in the study area. Pollutant loadings from sewage and industrial treatment plants, urban stormwater runoff systems, vessel wastes, and agricultural lands will steadily increase. The impact on water bodies will be more thoroughly discussed in the Water Resources section of this appendix.

A.5.3. Employment in the commercial fisheries and trapping industries has varied considerably due to changing market conditions and the availability of locally produced fish and wildlife resources and imported seafood. The most dramatic shifts in employment have been in the commercial fisheries industry. During the period 1970-1979, the number of wholesalers and processing plants and the amount of seasonal and yearly employment showed a declining trend.

A.5.4. In 1937, there were 25 oyster canners in Louisiana and Mississippi. These canners were packing several hundred thousand cases per year. In 1977, the number of canners in both states had dwindled to four with a production of about 75,000 cases. For many years Louisiana and Mississippi oysters thrived on natural and cultivated beds and reefs. The lack of optimum salinity conditions has reduced oyster production so severely that the industry has practically died in Mississippi and is struggling to survive in Louisiana. Nationally, there is a great demand for canned and fresh oysters. As the oyster industry on the Louisiana-Mississippi Gulf Coast declined, Japan and Korea encroached on much of the canned oyster market.

A.5.5. Table A-5-1 shows the number of fishery wholesalers and processing plants in Louisiana. In the processing plants category, the number of canned fisheries product plants decreased by 47 percent during the period 1970-1979. The number of industrial fishery product plants decreased by 28 percent in the same period. Loss of jobs followed this decrease and diminished the processor's capability to meet the population demand. As a result, fisheries products have had to be imported to meet the increasing demand.

A.5.6. The closing of the many fishery processing plants has been linked to the processor's inability to obtain a steady supply of fish stocks. The fish harvest has varied widely from year to year. The commercial fisheries harvest, based on 1963-1978 landings, presently averages 96 million pounds per year. Based on 1982 prices, average annual dockside value of these landings was $52 million. Due to the projected decline in habitat conditions, the fisheries harvest is expected to decline significantly by the year 2040. Stabilizing the commercial fisheries harvest would greatly benefit the industry. A stable harvest would give the fisheries processing industries an opportunity to concentrate on expanding their market area.

TABLE A-5-1

LOUISIANA FISHERY WHOLESALERS AND PROCESSING PLANTS

Year	Wholesale Plants	Processing Plants		
		Canned Fishery Products Plants	Industrial Fishery Products Plants	Others
1970	113	-	-	110
1971	51	19	29	136
1972	105	19	28	84
1973	108	18	22	81
1974	99	17	23	87
1975	101	16	19	75
1976	98	13	18	76
1977	91	12	24	73
1978	115	10	25	101
1979	115	10	21	96

Source: Fisheries of the United States, 1971 through 1980, National Marine Fisheries Service, US Department of Commerce.

A.5.7. Similar trends of declining employment and catch can be detected in the commercial wildlife industry, including furbearer and alligator harvest. In the Louisiana portion of the study area, potential annual net value of commercial wildlife is about $800,000. Due to declines in quantity and quality of habitat, potential annual value of commercial wildlife would be reduced by over $378,000 by 2040.

LAND RESOURCES

A.5.8. Louisiana contains approximately 41 percent of the coastal wetlands in the contiguous United States (Turner and Gosselink, 1975).

Studies in 1970 indicated that coastal Louisiana was experiencing a net land loss of 16.5 square miles per year (Gagliano and Van Beek, 1970). In 1980, studies revealed that the rate of marsh loss has significantly increased and is estimated to be 39 square miles per year in the area covered by the Mississippi Deltaic Plain Ecological Characterization (Wicker, 1980). Plate A-7 depicts the areas and severity of land loss in coastal Louisiana from 1955 to 1978. Marsh loss rates range from low (0-1 ac/mi/yr) to very severe (4 ac/mi/yr). Recent marsh loss rates for the Lake Pontchartrain Basin and Mississippi Sound area are estimated at 2.5 and 0.34 square miles per year, respectively.

A.5.9. In Louisiana, land loss is the result of a combination of natural processes and man's activities. Formerly, the Mississippi River migrated back and forth across the area developing a series of deltas. This process formed a deltaic plain that extended the landmass gulfward. Each year, the river would overflow the study area and deposit a layer of sediment. The influx of sediments maintained the growth of the land mass. When the river was leveed off to protect development from disastrous seasonal flooding, sedimentation in the area ceased. Deprived of the annual sediment inputs, the forces of deterioration dominated the area. The result was compaction, subsidence, and erosion. The shorelines in the area are retreating steadily. The deltaic masses have retreated at rates of 13.7 to 16.2 feet per year resulting in land loss rates of 1,670 to 2,083 acres per year prior to 1960 (Craig et al., 1978). In Mississippi, land loss is less prominent.

A.5.10. Land loss has been accelerated by the construction of numerous canals for navigation, drainage, and exploitation of renewable and nonrenewable resources. A total of 16.6 square miles of canals had been dredged in the Lake Pontchartrain Basin by 1970 (Gagliano et al., 1973). These canals have lengthened the tidal shorelines by 351 miles in the Lake Pontchartrain Basin (Becker, 1972). As the canal area has

increased, saltwater has invaded further inland and wave attack on the weak marsh soils especially from boat wash has increased.

A.5.11. The cumulative effect of natural processes and man's activities has drastically reduced the land mass and habitats available for wildlife. Table A-5-2 displays the acreage change in selected habitat types in the study area for the years 1956 to 1978. The habitat types critical to fish and wildlife are expected to decline further by the year 2040. The area is expected to lose approximately 91,000 acres of marsh by the year 2040. Thus, there is a need to reduce the rate of land loss and to restore or maintain the viability of wetlands habitats.

TABLE A-5-2

ACREAGE CHANGES IN SELECTED HABITAT TYPES
1956 to 1978

Bottomland Hardwoods and Wooded Swamp		Fresh Marsh		Non-Fresh Marsh 1/	
1956	1978	1956	1978	1956	1978
348,700	279,401	72,416	36,470	340,649	263,135

Source: Modified from Wicker (1980).

1/ Includes intermediate, brackish, and saline marsh types.

WATER RESOURCES

A.5.12. Water quality in Lakes Pontchartrain and Maurepas is influenced to a large part by land use activities in the basin. The lakes are receiving municipal and industrial wastewaters and urban stormwater runoff from over 25 urban areas in the northern portion of the basin,

the largest of which is the city of Baton Rouge. These waters contain oxygen-demanding materials and toxic substances that have placed stresses on the ecological system in the lakes. Over 79,000 acres of agricultural crop lands are in the upper Lake Pontchartrain basin. Although outside the study area, excessive runoff from these lands contains pesticides, nutrients from chemical fertilizer, and sediments that enter Lakes Pontchartrain and Maurepas. The constituents in the agricultural runoff contribute to water quality degradation. To the south, the New Orleans Metropolitan area discharges urban stormwater runoff, municipal wastewater from Jefferson Parish, and waste from camps into Lake Pontchartrain. All of these activities have stressed the ecological system of the lakes. Due to high fecal coliform counts along the shores of Lake Pontchartrain, swimming along the southern shore is not advised. On the north shore, swimmers are advised to stay out of the water within 200 yards of where streams and other waterways enter the lake. The projected population incresae will further stress the lakes.

A.5.13. Saltwater intrusion into the lakes has resulted in the loss of wetlands. Rising salinity levels have killed baldcypress swamps in Tangipahoa, Livingston, St. John the Baptist, St. Bernard, and St. Charles Parishes. Increased salinities have converted freshwater marshes to more salt-tolerant intermediate and brackish marshes.

A.5.14. During the summer months, occasional fish kills occur along the southern shore of the lake as a result of the lack of oxygen and the presence of toxic substances. Lake dredging for clamshells is causing concern among environmental groups and state and local agencies. Shell dredging may kill many bottom organisms and contribute to pollution problems by disturbing the lake's muddy bottom, releasing toxic substances back into the water.

A.5.15. Water quality in Lake Borgne is largely determined by the quality of water entering from Lake Pontchartrain, Pearl River, Mississippi Sound, Gulf Intracoastal Waterway, MR-GO, and Bayou Bienvenue. Lake Borgne water quality is slightly better than Lake Pontchartrain water quality. However, because of the high coliform counts from urban stormwater runoff, municipal waste, and waste from camps, the Lake Borgne oyster harvesting areas are continually threatened with closure. The MR-GO provides an avenue for the intrusion of higher salinity water and, as a result, formerly freshwater habitat has been converted to intermediate and brackish marshes. The Mississippi Sound water is generally good quality. However, high fecal coliform counts have been recorded adjacent to the shoreline particularly where rivers and streams enter the sound.

A.5.16. The water bodies in the Louisiana portion of the area are expanding rapidly due to the combined effects of subsidence, erosion, and a general rise in sea level. As a result, the surface area of the water bodies are expected to increase.

A.5.17. The activities of man are accelerating the natural expansion of the water bodies. Canal dredging has increased the water surface area. The length of the shoreline affected by tides and waves has also increased exposing even more marsh to wave attack. The marsh soils are easily eroded by wind-driven waves and wave wash from boat traffic. These factors have contributed to the increased width of canals. The annual increase in canal width has been estimated at 2 to 5 percent per year (Craig et al., 1978).

HABITAT DETERIORATION

A.5.18. Subsidence, compaction, and erosion have historically and in the future will continue to convert large areas of coastal marshes to open water. Man's activities have also accelerated and will continue to accelerate marsh loss. Man-made alterations have virtually eliminated the historical processes of overbank flooding and distributary flow, depriving coastal wetlands of the fresh water, nutrients, and sediments vital to their existence. Activities associated with dredging also cause direct marsh losses and can provide avenues for salt water to intrude into the marshes.

A.5.19. When salt water intrudes into a fresher area, vegetation is gradually killed. Before more saline-tolerant plant species can revegetate, open water areas are often created because the root systems of the original vegetation that helped to hold the marsh substrate together have been lost. The greatest damage to marsh plants in coastal Louisiana occurs when fresh marshes with highly organic soils are subjected to much higher salinity levels and strong tidal action. Plants in these areas are killed by the elevated salinity levels and the organic substrate becomes loose and disorganized without the stabilizing effect of plant roots. When this occurs, organic soils are flushed from the affected areas and the emergent marsh is replaced with open ponds and lakes. As marsh is lost and open water areas are created, the total area of interface between water and marsh is increased, leading to increased erosion. The marsh remaining in areas affected by saltwater intrusion is more saline than the original marsh. In general, land loss and saltwater intrusion create an ever-increasing cycle of wetland deterioration.

A.5.20. Construction of the MR-GO resulted in direct loss of approximatley 24,000 acres of habitat to channel excavation and dredged material disposal areas. In addition, the MR-GO allowed increased erosion and saltwater intrusion. Following construction in the late 1950's and early 1960's, salinities in the wetlands of St. Bernard Parish increased three-fold, converting large acreages of fresh marsh to open water and more saline marsh types and eliminating certain areas of wooded swamp. Bald cypress swamps existed at the base of the Mississippi River natural levees and graded into fresh and brackish swamp toward Lake Borgne. (O'Neil 1949). Due to the construction of the MR-GO and the resulting increased salinities, approximately 9,705 acres of formerly fresh marsh and bald cypress swamp have been changed to brackish marsh. About 914 acres of bald cypress swamp still exist in a decidedly stressed condition. By 1978, seasonal high levels in Lakes Pontchartrain and Maurepas caused approximately 25,000 acres of fresh marsh and cypress-tupelo swamps to be converted to nonfresh habitats. In this area, almost 21,000 acres of the swamp were converted to marsh. The conversion was predominantly in the lower Pearl River near the Rigolets and in the vicinity of Pass Manchac. About 30,000 acres of cypress-tupelo swamp on both the north and south shores of the Bonnet Carre' Spillway in St. Charles Parish are now considered stressed.

A.5.21. The reality of past saltwater intrusion can be observed by inspecting plates A-8 and A-5. Plate A-8 shows the approximate boundaries between fresh and nonfresh marshes in the Mississippi Deltaic Plain Region in the 1950's. The nonfresh marshes shown on this map include intermediate, brackish, and saline marshes. Plate A-5 shows the approximate boundaries of fresh, intermediate, brackish, and saline marsh types in the same region in 1978. The extent of the inland shift can be observed by comparing the boundary between the fresh and nonfresh marsh on the 1950 map with the boundary between the fresh and intermediate marshes on the 1978 map. The brackish-saline marsh

boundary has also shifted inland. Additional information substantiating saltwater intrusion is demonstrated by the inland extension of oyster leases. Plate 9, pre MR-GO oyster leases, and plate 10, post MR-GO oyster leases, provide evidence of the inland extension of oyster leases. Saltwater intrusion is implicated as the major factor in the inland movement of oyster leasing areas.

A.5.22. Wildlife. Louisiana's vast wetlands provide wintering habitat for over two-thirds of the Mississippi Flyway waterfowl as well as other migratory game birds including rails, gallinules, and snipe (Bellrose, 1976). According to the Louisiana Department of Wildlife and Fisheries, over $25 million is spent on waterfowl hunting each year. The marshes south of Lake Borgne provided at one time the most important waterfowl wintering area in Louisiana for lesser snow geese, mallards, green-winged teal, and lesser scaup. Increased salinities in the area were responsible for development of less desirable waterfowl habitat. The area is now greatly reduced in value to all the species except the lesser scaup. According to the USFWS, this area once overwintered 250,000 waterfowl prior to construction of the MR-GO. Between 1969 and 1978, the area supported only about 10,000 wintering waterfowl annually.

A.5.23. Continued loss of fresh and intermediate marshes can be expected to result in a decline in harvest of furbearers. Over two-thirds of the state's fur harvest is derived from nutria, which exhibit the highest productivity in fresh marsh and the lowest in saline marsh. Furbearers were valued at $16.8 million for their pelts and meat during the 1979-1980 season. The alligator population, which also thrives in fresh and intermediate marshes, will be similarly affected. Expanding saltwater intrusion can be expected to damage a promising revival of the alligator industry that contributed $2 million to the local economy in 1980 (Fruge, 1981).

A.5.24. The combined effects of land loss and saltwater intrusion have resulted in severe adverse impacts on valuable wildlife resources. Land loss is expected to continue in the future. Reduced habitat has led to decreased wildlife populations including resident and migratory waterfowl, wading birds, shorebirds, furbearers, and a variety of small and big game animals. The losses have led to decreased commerical fur harvests and reduced opportunities for waterfowl, big game, and small game hunting.

A.5.25. Fisheries. Marsh loss and saltwater intrusion have had an adverse impact on fishery resources production and seriously threaten the Louisiana fishery resource. In coastal Louisiana, the majority of commercially and recreationally important finfish and shellfish species are estuarine-dependent since juveniles use the estuaries and adjacent wetlands as nursery areas. Louisiana's commercial fishery harvest represents over 25 percent of the total United States harvest every year. In 1980, approximately 1.4 billion pounds, valued at $178 million, were landed. In addition, estimates are that recreational fishing in Louisiana contributes $150 million annually to the state economy (Aquanotes, 1981). Historically, Louisiana's most valuable commercial fisheries have revolved around shrimp, menhaden, and oysters. These species, as well as the majority of other finfish and shellfish species important in Louisiana, depend heavily on estuarine ecosystems.

A.5.26. Improved technology and increased fishing effort prevented a decline in average annual harvests in recent years. These factors compensated for the decline in habitat. However, biologists project that if current trends in habitat reduction continue, harvests will diminish (Craig et al., 1979). Shrimp and menhaden yields have been directly correlated to the area of wetlands. Turner (1979) reported that the Louisiana commercial inshore catch is directly proportional to

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- Improve sport fishing opportunities to satisfy a portion of the sport fishing demands and to increase the quality of the fishing experience by not lowering the "expected catch".

- Improve sport hunting opportunities to satisfy a portion of the sport hunting needs.

- Provide additional access to fish and wildlife resources to increase recreation opportunities.

Section 7. PLANNING OBJECTIVES

A.7.1. Planning objectives that will enhance the national economic development (NED) are determined by the specific national, state, and local water and related land resource management needs in the study area. NED is achieved by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems.

A.7.2. The following objectives have been developed based on identified problems, needs, and opportunities and the concerns of the public and Federal, state, and local interests:

- Restore and maintain favorable salinity regimes in wetlands and estuaries to increase fish and wildlife productivity.

- Preserve, restore, and create natural habitat to offset potential declines in fish and wildlife populations and reduce erosion, subsidence, and avenues for saltwater intrusion.

- Increase commercial fisheries production to meet the demands for fish products, increase the number of jobs available, and stabilize the wide fluctuations in the fisheries industry.

- Enhance growth of marsh and aquatic vegetation to reduce land loss and increase the nutrient supply for fish and wildlife productivity.

- Increase commercial wildlife production to meet the demand for pelts and hides, increase the number of jobs available, and stabilize the wide fluctuations in the wildlife industry.

A.6.5. In the optimum salinity regime, salinities will be allowed to vary rather than attempting to constantly maintain levels at 15 ppt. The Memorandum for Record signed by the ad hoc group documentating the group's conclusion and recommendations is in Appendix B, Plan Formulation. The Department of Wildlife and Fisheries indicated if a good crop of seed oysters is produced one out of 2 to 3 years on the average, the amount of oysters produced would more than enough to sustain a significant expansion in the oyster industry. The freshwater diversion structures should be designed for diverting sufficient freshwater to establish this salinity regime 4 or 5 years in 10, in a 50 percent drought condition.

maintained to significantly increase oyster harvest. The proposed salinity regime is based on data collected over a 10-year period, 1971-1981, on Louisiana's most productive seed grounds in Breton Sound Basin. Salinity data and seed oyster production data were analyzed to determine optimum salinity conditions. The proposed salinity regime mimics salinity conditions that existed when the Mississippi River overflowed its banks in the early part of the year. A large portion of formerly productive public oyster seed grounds in the Lake Pontchartrain-Borgne Basin in St. Bernard Parish that would be directly benefited by maintaining an optimum salinity regime. The ad hoc group agreed that the salinity regime proposed by Louisiana Department of Wildlife and Fisheries should be established at the Ford and Palmisano lines. The recommended mean monthly salinities are shown below and on Plate A-12.

Month	Mean Optimum Salinity (ppt)	Standard Error (ppt)
January	16.4	1.04
February	14.4	0.79
March	11.6	1.02
April	8.0	1.27
May	7.0	0.92
June	12.5	0.80
July	12.7	0.57
August	15.7	0.80
September	17.0	1.06
October	16.8	0.87
November	16.1	0.82
December	15.7	0.52

Maintaining the Ford line was required to maximize productivity in the commercial and sport fishery resources. The location of the line is not based on historically documented salinity conditions. The line was envisioned as a location that would increase the nursery areas used by marine fisheries and restore oyster reefs to their former high productivity. The Palmisano line marks the brackish-saline marsh contact that is designated as an initial line for defining salinity requirements for marsh communities. The fresh-to-brackish marshes are the preferred habitat of the important commercial and sport wildlife species. Wildlife productivity is directly correlated with plant growth and composition (Palmisano, 1973).

A.6.3. Subsequent hydrologic analysis indicated that year-round freshwater diversion would be required to maintain the desired salinity conditions. During the diversion, the 5 ppt isohaline would be pushed into Lake Borgne. Biologists indicated that year-round diversion might cause more adverse than beneficial impacts. Based on these findings, the ad hoc group was reconvened in May 1982. The group included Louisiana Department of Wildlife and Fisheries, NMFS, USFWS, Mississippi Department of Wildlife Conservation, Bureau of Marine Resources, Louisiana Department of Natural Resources, Louisiana Department of Health and Human Resources, Louisiana Office of Public Works, and the Corps of Engineers. The ad hoc group agreed that the positions of the Ford and Palmisano lines should be reconsidered. A subcommittee was formed to review pertinent information and develop new or optimum salinity conditions or modify the conditions established by the interagency ad hoc group in 1969-1970.

A.6.4. The Louisiana Department of Wildlife and Fisheries proposed a salinity regime that could be established. The agency affirmed that seed oysters are the limiting factor in increasing oyster production in Louisiana. Consistently high levels of seed oyster production must be

Section 6. PLANNING CONSTRAINTS

PROBLEM ANALYSIS

A.6.1. In the estuarine-marsh complex, there is a synergistic relationship between freshwater, sediment, nutrients, levels of salinity, and resource productivity. To analyze the advisability of altering one characteristic in the area requires that these environmental parameters be addressed as a whole, not individually. However, associating reduction and changes in the salinity gradients with increases in primary productivity of habitat types and fish and wildlife populations is a complex problem. Actual experience with diversion for the purpose of conserving and enhancing fish and wildlife resources is limited in scope and duration. The current knowledge of the relationship between changes in physical and chemical parameters and biological communities is based largely on inductive reasoning and expert judgment. There is no single accepted method for relating primary productivity to fish and wildlife harvest and to the benefits to be derived from reducing salinities. Studies to refine current information would require several years of basic research, extensive data collection, and development of hydrologic and water quality models. The effort could take 4 years or more to accomplish. In view of these constraints, the most reasonable approach is to limit the study effort to review and evaluation of existing information and available data.

SCALE OF DEVELOPMENT

A.6.2. Initially, the objective was to attain the optimum salinity regime determined by an interagency ad hoc group in 1969-1970. The optimum salinity regime (plate A-11) is established when the average position of the 15 ppt isohaline is maintained at the Ford line April through September and the Palmisano line October through March.

gulls, terns, raptors, and songbirds, and provide important habitat for other nongame wildlife such as reptiles, amphibians, and small mammals.

RECREATIONAL RESOURCES

A.5.33. The opportunities for sport fishing and hunting in the area are related to the availability of access to the fish and wildlife resources. The quality and quantity of the sport fish and wildlife resources depend on the habitat conditions. Deterioration in these conditions reduces productivity of important game species thereby reducing the sportsman's success. Projected adverse habitat changes could reduce potential opportunities for sport hunting by 39 percent by the year 2040. The potential opportunities for sport fishing and hunting are further constrained by lack of access. The need for boat launching ramps is expected to increase from 1,160 lanes in 1980 to 1,862 in 2040. Thus, there is a need for improving recreation resources of the study area.

CULTURAL RESOURCES

A.5.34. Cultural resources in the area are located mainly along abandoned natural levees of the Mississippi River, its abandoned distributaries and numerous other bayous. Many archeological sites such as Fort MaComb and Fort Pike, are being adversely affected by subsidence and erosion, as well as urban and industrial expansion. Opportunities available to reduce these adverse effects would be beneficial to cultural resources in the area.

A.5.35. The opportunities available to enhance habitat conditions and partially reduce the land loss rate are: regulate alteration of wetlands, fill open water areas with dredged material to create new marsh, construct saltwater intrusion barriers, and introduce fresh water and sediment into the wetlands.

NEEDS AND OPPORTUNITIES

A.5.29. The declining employment and catch trends clearly indicate a need to stabilize the harvest of the commercial fisheries and wildlife industries. The opportunity exists to accomplish this need by enhancing habitat conditions.

A.5.30. Reducing salinities would restore low-salinity areas where these zones have been eliminated or greatly reduced by saltwater intrusion. Restoring the areas would benefit species that require such zones as nursery habitat. Samples taken throughout the Louisiana coastal zone have shown the greatest catch of juvenile white shrimp, blue crabs, menhaden, and other finfishes in lower salinity waters. Reducing salinities would prove invaluable in improving and restoring oyster-producing areas, especially areas where encroaching salinities have allowed the southern oyster drill and other predators and disease organisms to move in over the oyster reefs. Reducing salinities to less than 15 ppt is an important control measure. Control of the oyster drill is the primary reason the State of Louisiana constructed diversion structures at White's Ditch and Bayou Lamoque in Plaquemines Parish.

A.5.31. Reducing the rate of land loss would restore and maintain the productivity of wetland habitats and enhance fish and wildlife resources. Increased plant growth would also increase production of organic detritus. The increased nutrient inflow would increase production of phytoplankton and zooplankton and may lead to greater harvest of sport and commercial fish and shellfish directly or indirectly dependent on these microscopic organisms.

A.5.32. Preserving the wetland habitat would benefit many species of nongame, noncommercial fish and wildlife. These wetlands are of great importance to the well-being of migratory birds such as shorebirds,

salinities lower than 5 ppt cause osmoregulatory difficulties in oysters and reduced reproductive capabilities. However, grave problems occur when salinities exceed 15 ppt. Above this level, oysters are subject to considerable predation, parasitism, and disease. The most important enemies of oysters in higher salinities include a carnivorous conch, the southern oyster drill (Thais haemostoma), and the fungus Labyrinthomyxa marina. The black drum, Pogonia cromis, is also a serious oyster predator at certain times. Other notable enemies include boring sponges, polychaete worms, boring clams, and stone crabs. Butler (1953) reported that the southern oyster drill was probably the most destructive single agent affecting the oyster industry in Louisiana and the other gulf states. It is generally assumed and reported (Chapman, 1959) that average salinities in excess of 15 ppt favor oyster drill populations. Perret et al. (1971) reported the majority of drills were caught at salinities above 15 ppt. Burkenroad (1931) reported that salinity seems to be the most important limiting factor for the southern oyster drill. Butler (1953) stated, "The only real barrier to snail (southern oyster drill) migration is a chemical one - lack of sufficient salt in the water. They are normally absent from those areas having a sustained salinity level of less than 15 ppt." The southern oyster drill has plagued the Louisiana oyster industry for years. St. Amant (1938) stated that oyster drills caused estimated losses in oyster production as high as 50 percent statewide. May and Bland (1969) observed that during a 9-month period, over 85 percent of the oysters in a high salinity area were killed by drills. Dugas (1977) reported that oysters remaining in high salinity areas throughout the summer generally encounter high mortalities from oyster drill predation. Based on the above discussion, the importance of maintaining salinities less than 15 ppt over oyster-producing areas becomes obvious.

TABLE A-5-3

OPTIMUM AND CRITICAL SALINITY RANGES*

Species	Spawning Locations	Peak Spawning Period	Period of Peak Juvenile Abundance	Optimum Salinity	Critical Salinity and/or Temperature Relationships
American Oyster	On oyster grounds (sessile)	May-September 1/ peaks when temperature is 27°C 2/	May-September 1/	5-1[illegible] ppt for seed oysters; 1[illegible]-2[illegible] ppt on bedding grounds; above 10 ppt for reproduction 1/	Exposure to salinities [illegible] when temperature greater than [illegible] causes mortality 4/. Oysters [illegible] to heavy predation by southern oyster drill at salinities above 1[illegible] ppt [illegible]
Brown/Shrimp	Open gulf 3/	March-May 5/	March-May 5/	15-20 ppt best for rapid growth for juveniles 6/	Salinities below 10 ppt and temperatures below 20°C occurring after first week of April lead to decreased growth and survival of post-larvae 6/ 7/ 9/
White Shrimp	Open gulf 3/	Late spring-early summer; late fall-early winter 5/	Main influx of post-larvae in June-August; smaller influx of over-wintering sub-adults in spring 5/	0.5-10 ppt 9/	Growth of juveniles best at 2[illegible]°C, growth negligible below 1[illegible]°C [illegible]
Blue Crab	Copulate in low salinity waters 3/ females migrate to waters greater than 21 ppt to spawn, usually in open gulf or bays 10/	June-August 10/	January-March; June-July 11/	Peak juvenile catches below 5 ppt 3/	Inconclusive.
Menhaden	Gulf 3/	October-March 3/	Summer months 3/	Between 10 and 12 ppt 12/	Optimum catch in 25-35°C waters 12/
Atlantic Croaker	Offshore and deep Passes 3/	Fall-winter 3/	Spring-summer 3/	Peak juvenile abundance less than 5 ppt 3/	Inconclusive, greatest juvenile abundance 20-30° 3/
Spotted Seatrout	Estuaries and lagoons 3/	March-November; peaks when water temperature between 22-25°C and where salinities are 34-36 ppt 3/	Data inconclusive species in estuary entire year	5-20 ppt 3/	Abrupt decreases in salinity or temperature can cause mass movement to more saline areas 3/
Red Drum	Open ponds and along sand beaches 3/	September-January 13/	Data inconclusive; species in estuary entire year	Data limited; most larvae and juveniles occur at 0-26 ppt; bigger fish prefer higher salinities 16/	Extremes in temperature and salinity tolerated; sudden temperature drops (cold fronts) may cause mortality 14/ greatest catch of juveniles in 5-15°C range 3/

Source: Modified from US Fish and Wildlife Service (1980).

* Numbers in table refer to citations listed below.

1/ Dugas, 1977.
2/ Dugas, 1979.
3/ Lindall, et al., 1972.
4/ Perret et al., 1971.
5/ White and Gaidry, 1973.
6/ Ford and St. Amant, 1971.
7/ Ford and St. Amant, 1971
8/ Gunter et al., 1964.
9/ St. Amant et.al., 1965.
10/ Fontenot, 1970.
11/ Adkins, 1972.
12/ Copeland and Bechtel, 1974.
13/ Yokel, 1966.
14/ Simmons and Breuer, 1962.
15/ Butler, 1953.
16/ Benson, 1981.

the area of intertidal wetlands, and that the area of estuarine open water does not seem to be associated with average shrimp yields. Cavit (1980), in work conducted for the USFWS, established that yields of menhaden increase as the ratio of marsh to open water increases. Harris (1973) stated that total estuarine-dependent commercial fisheries production in coastal Louisiana has peaked and will decline in proportion to the acreage of marshland lost.

A.5.27. Marshes produce large amounts of organic detritus that are transported into adjacent water bodies. Detritus is a very important component of the estuarine food web and is vital to maintaining the high level of fishery productivity in Louisiana (Darnell, 1961, Odum et al., 1973). Marshes and associated shallow water bodies are used by various life stages of many estuarine-dependent species that take advantage of the protection from predators, warmer temperatures, optimal salinity regimes, and the rich detrital food chain. Many important sport and commercial species depend on shallow marsh areas. They include the Atlantic croaker (Rogers, 1979), menhaden (Simoneaux, 1977), brown and white shrimp (White and Boudreaux, 1977), and blue crab (More, 1969). Conner and Truesdale (1973) demonstrated the value of shallow marsh habitat to juvenile brown and white shrimp, gulf menhaden, Atlantic croaker, sand seatrout, and southern flounder.

A.5.28. Saltwater intrusion has narrowed the broad brackish, low salinity zones that are vital for the juvenile stage of most important commercial and sport finfish and shell fish. Table A-5-3 shows the optimum and critical salinity ranges for the important fish and shellfish resources. The rising salinities have reduced the low-salinity nursery habitat important to white shrimp and blue crab. Saltwater intrusion is particularly harmful to the American oyster. The optimal salinity range for growth and survival of oysters is 5-15 ppt (Galtsoff, 1964, St. Amant, 1964, Loosanoff, 1965). Prolonged

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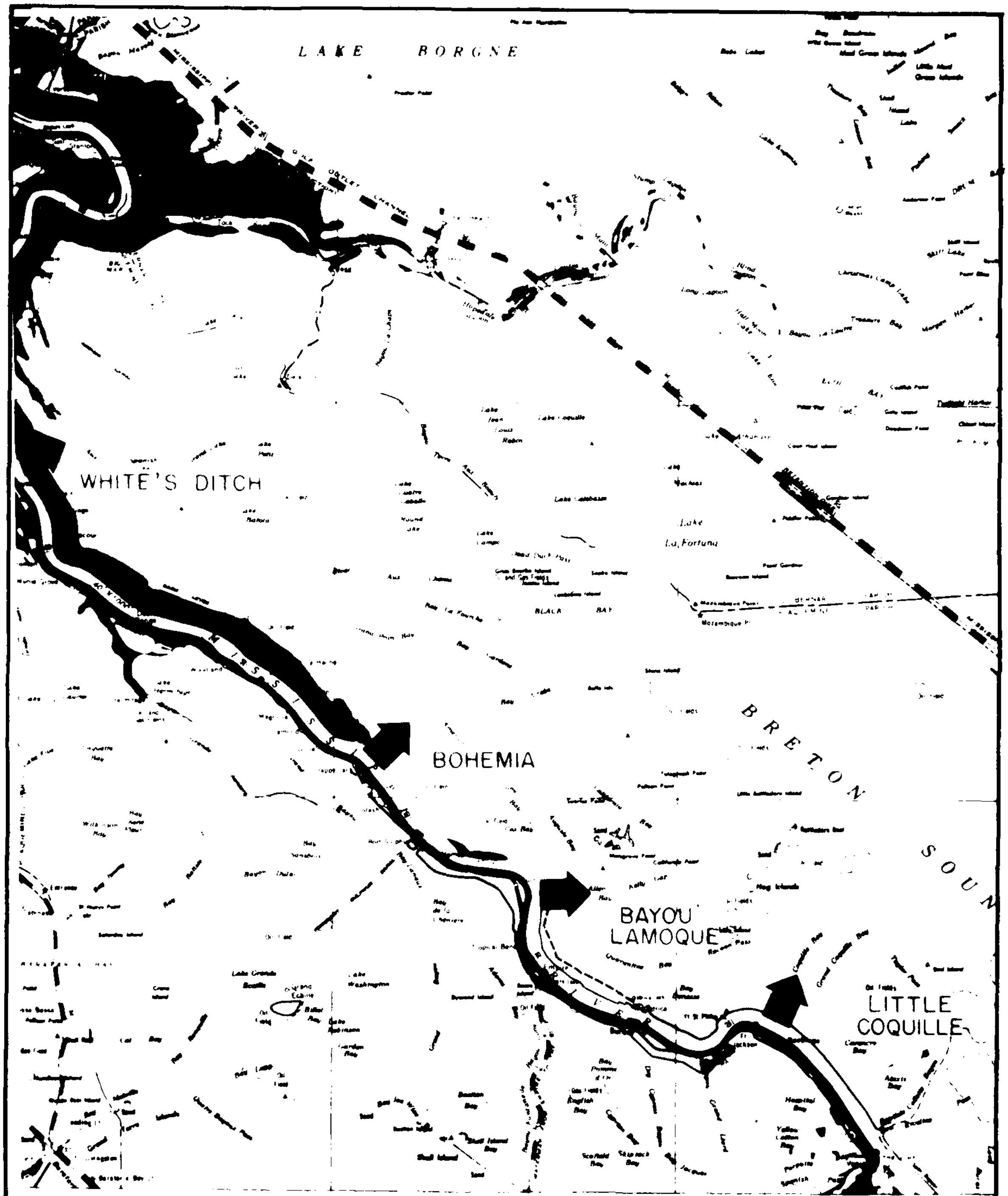
PLATE A



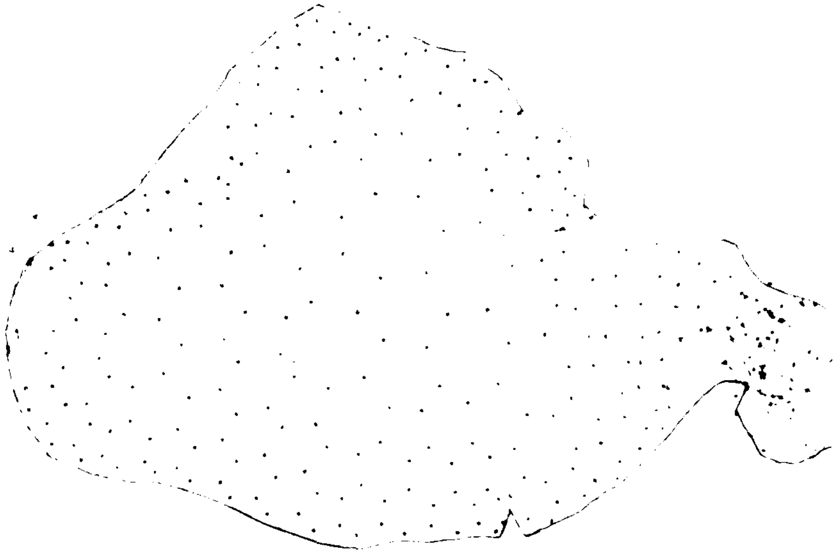
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

STATE CONSTRUCTED FRESHWATER DIVERSION STRUCTURES

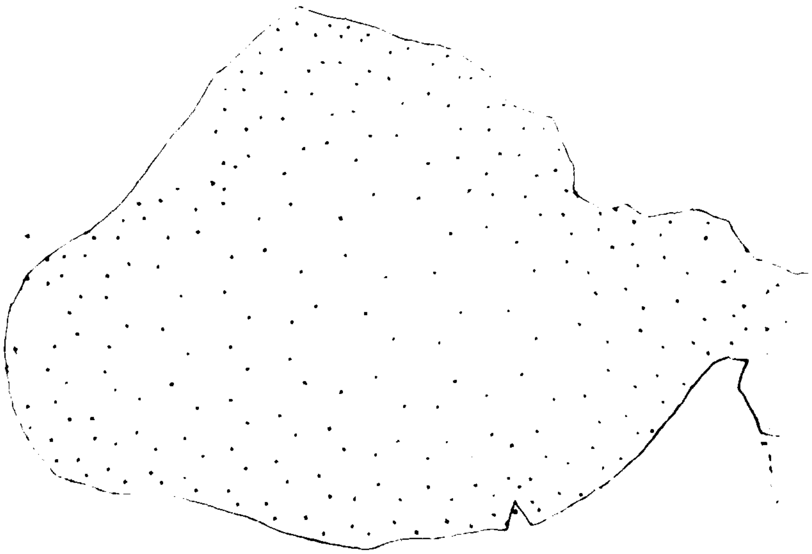
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

PLATE A-2



INCOMING TIDE



OUTGOING TIDE

MISSISSIPPI AND LOUISIANA
ESTUARINE AREAS

CIRCULATION PATTERNS IN
LAKE PONCHARTRAIN DURING
THE SPRING WITH
SOUTHEASTERN WINDS

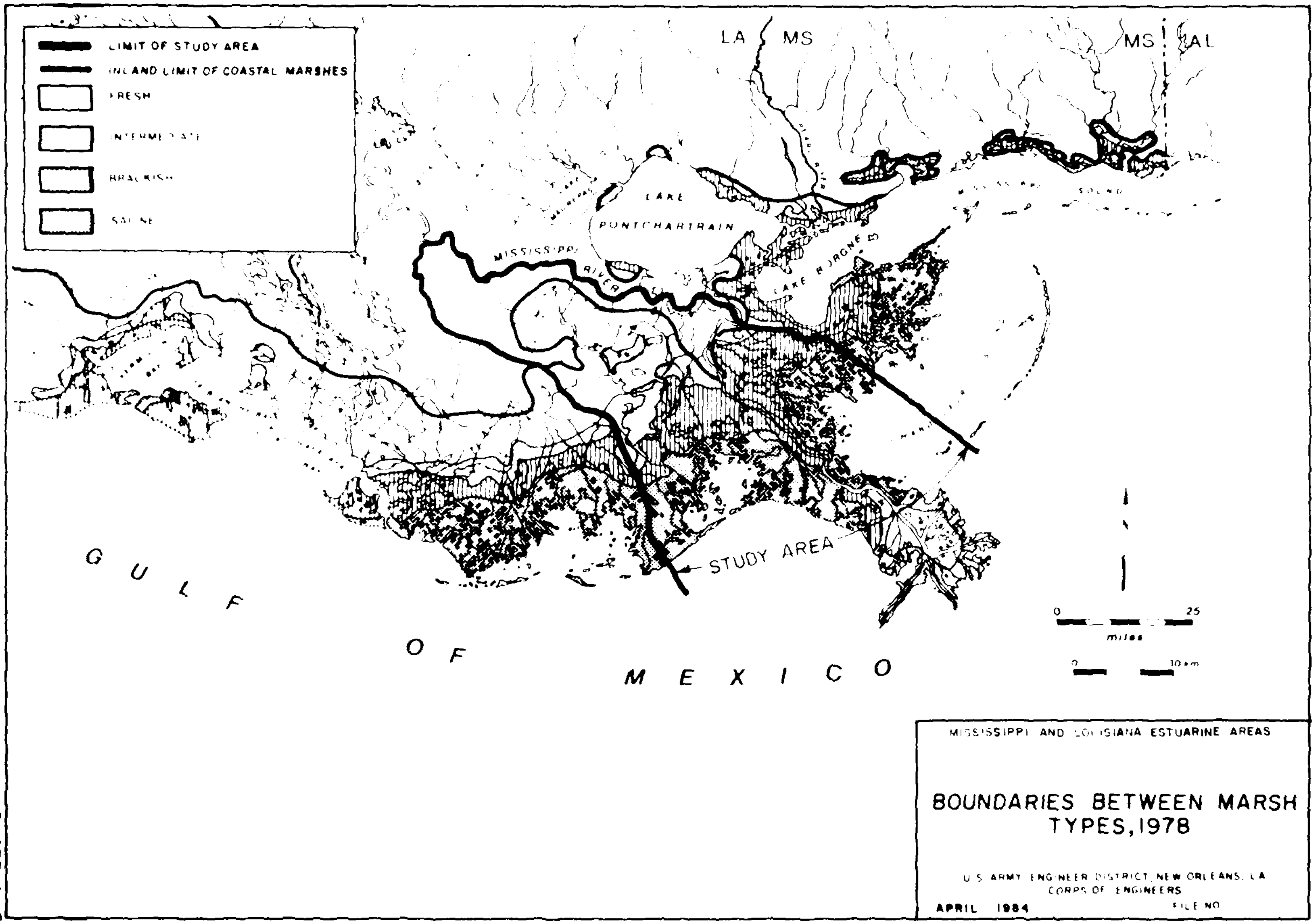
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO. H-2-29532

PLATE A-3


LEGEND
GENERALIZED CURRENT CIRCULATION
TIDAL CURRENTS AND SURGE
LONGSHORE DRIFT
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS
GENERALIZED CIRCULATION PATTERNS IN THE MISSISSIPPI SOUND
ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
APRIL 1984
FILE NO.
Gulfport
Pascagoula
Pass Christian
HANCOCK COUNTY
HARRISON COUNTY
MISSISSIPPI
LOUISIANA
INTRACOASTAL
WATERWAY
ST BERNARD PARISH
SOUTH ATLANTIC DIVISION
MOBILE DISTRICT
LOWER MISSISSIPPI VALLEY DIVISION
NEW ORLEANS DISTRICT
ALABAMA
MISSISSIPPI
PETIT BOIS ISLAND

PLATE A-4


LIMIT OF STUDY AREA
INLAND LIMIT OF COASTAL MARSHES
FRESH
INTERMEDIATE
BRACKISH
SALINE
LA
MS
MS
AL
LAKE PONTCHARTRAIN
MISSISSIPPI RIVER
LAKE BORGNE
STUDY AREA
GULF OF MEXICO
0
25
miles
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS
BOUNDARIES BETWEEN MARSH TYPES, 1978
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS, LA
CORPS OF ENGINEERS
APRIL 1984
FILE NO.
PLATE A-5

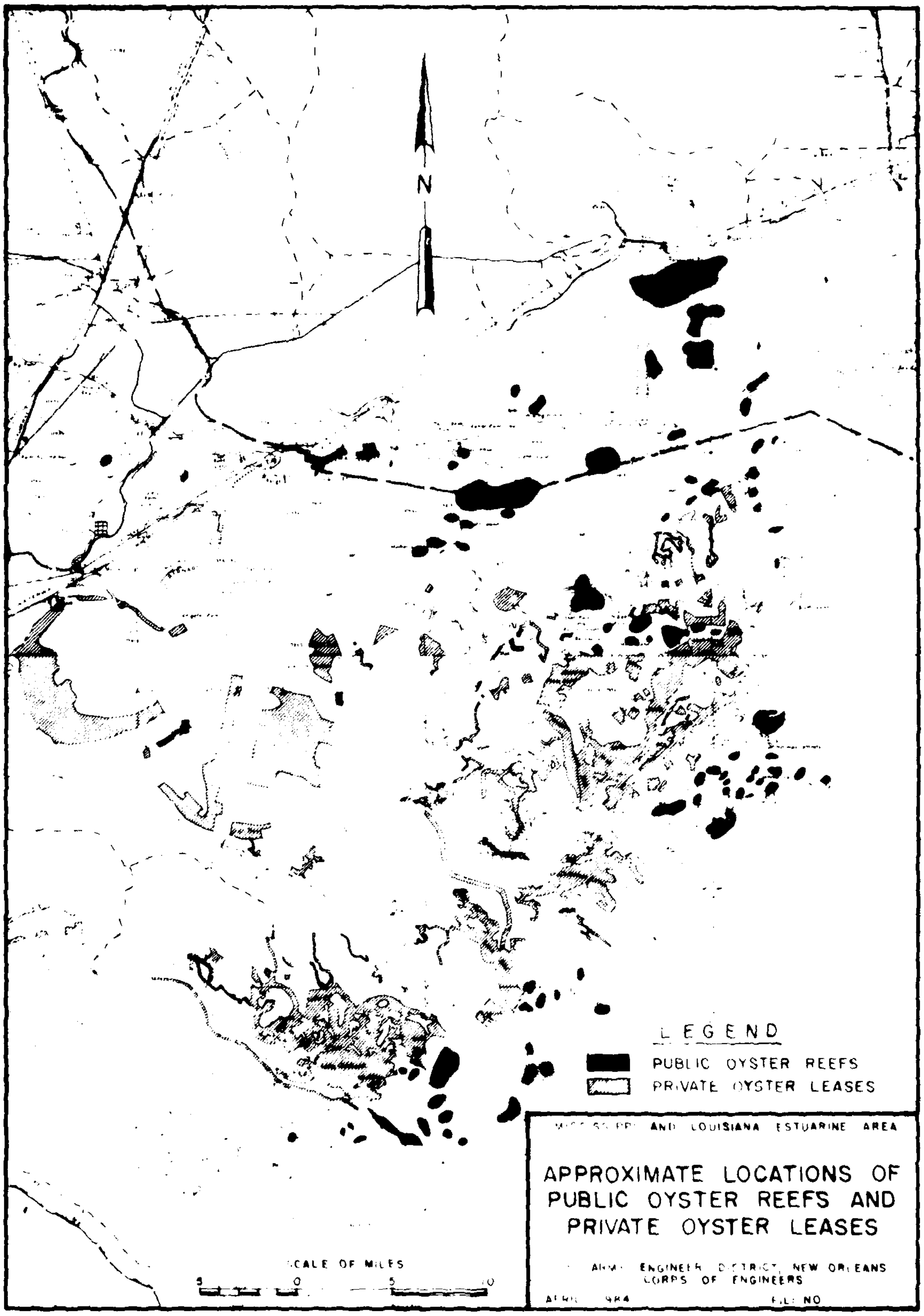
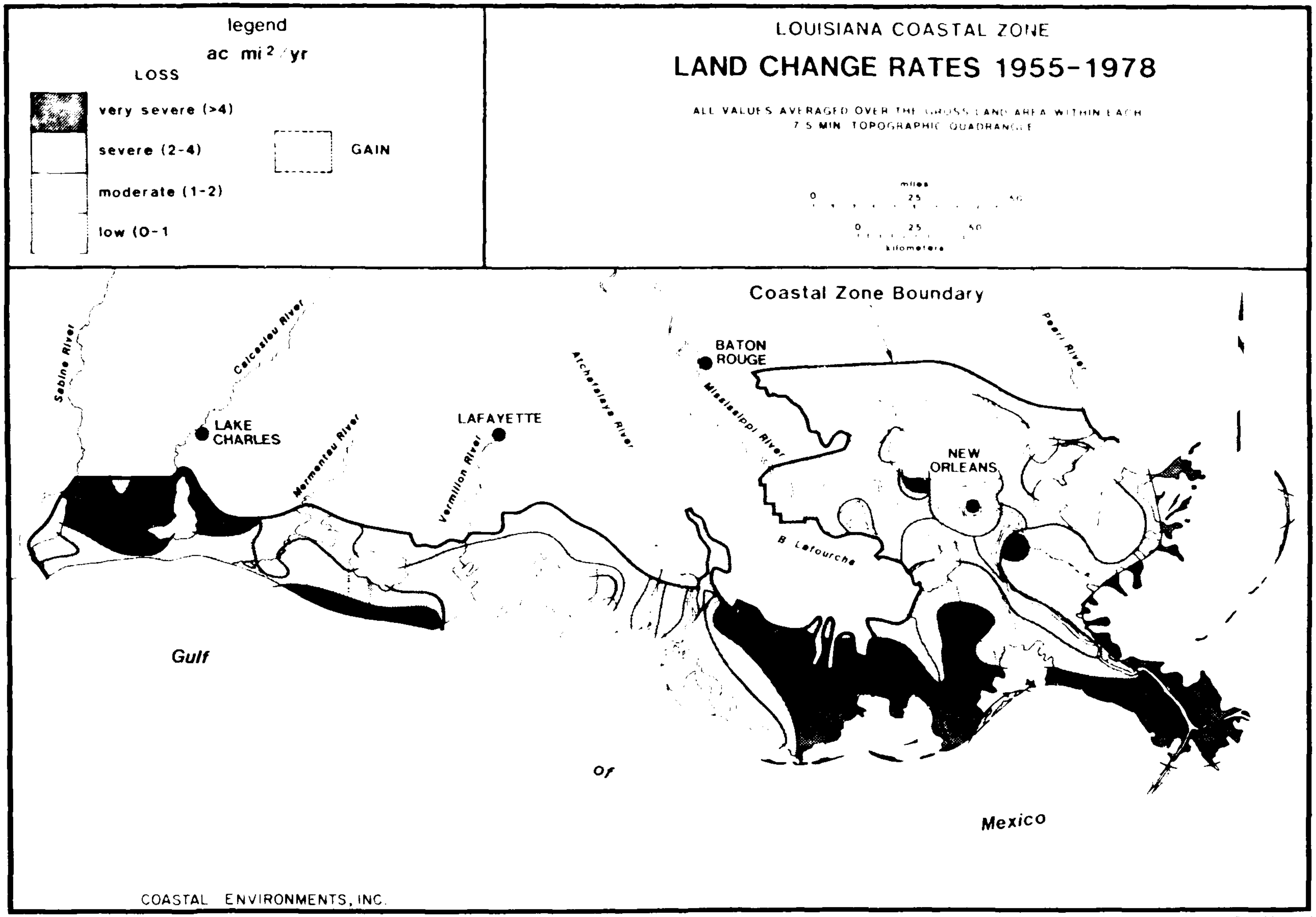
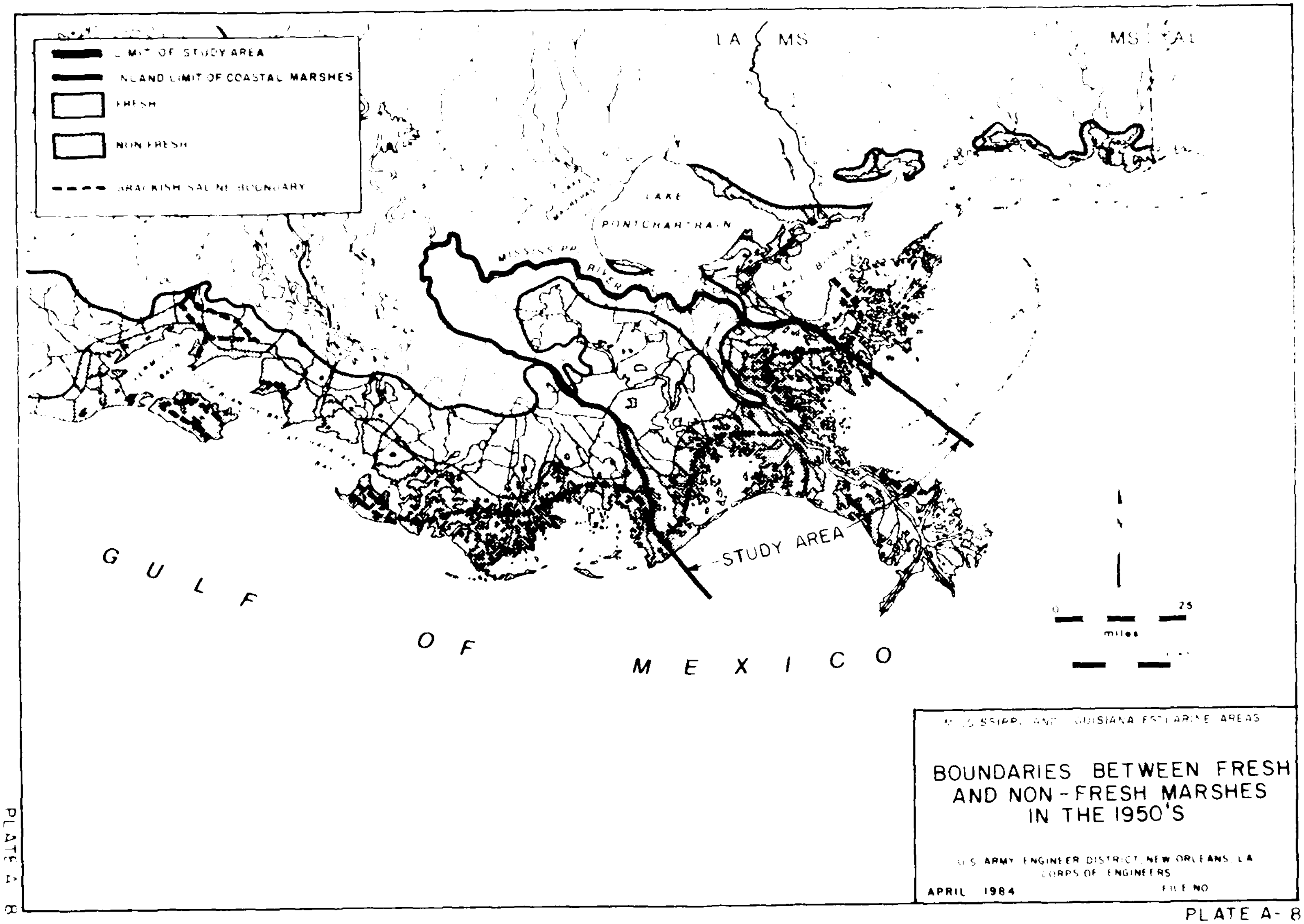
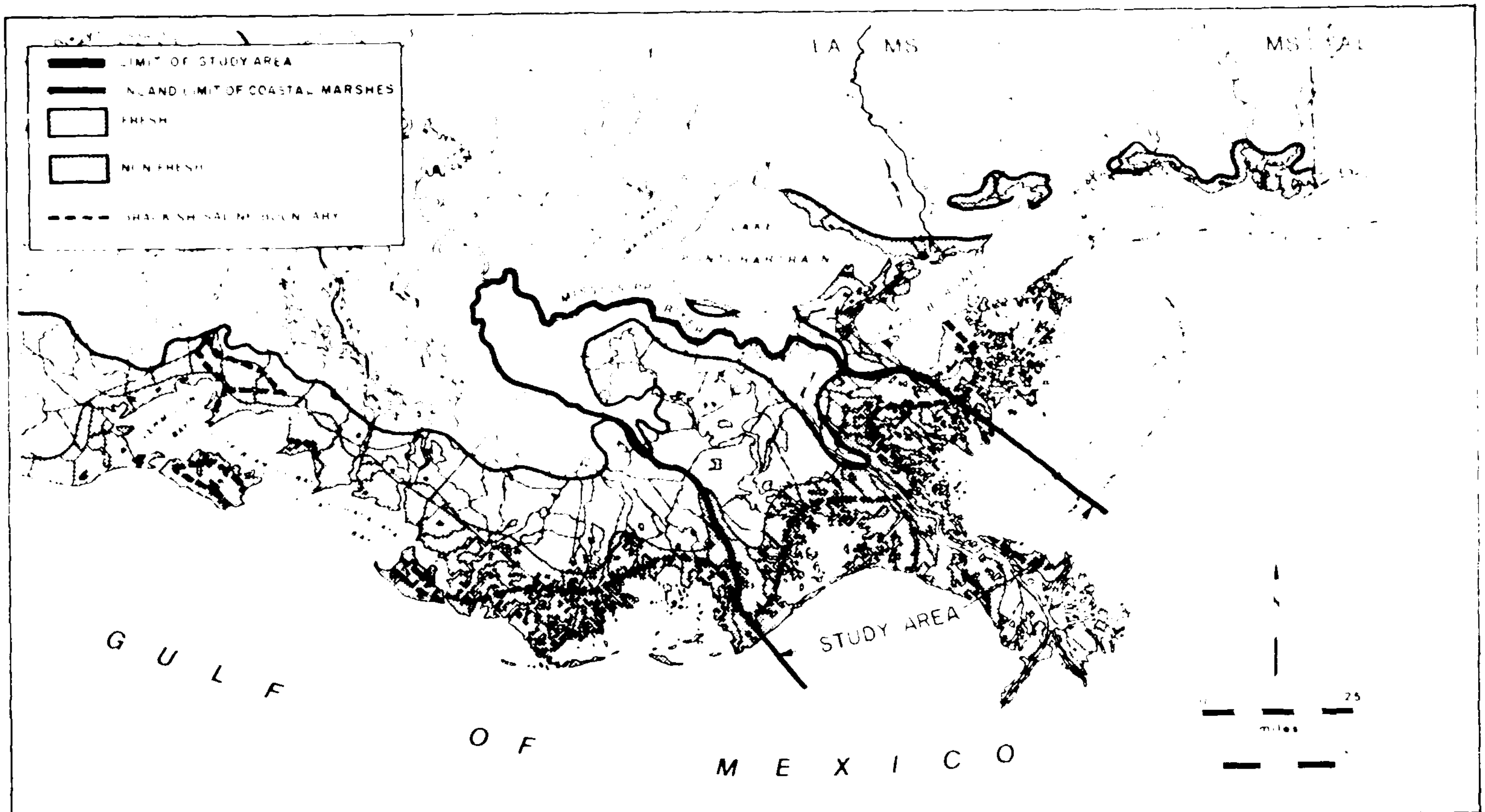

N
LEGEND
PUBLIC OYSTER REEFS
PRIVATE OYSTER LEASES
AND LOUISIANA ESTUARINE AREA
APPROXIMATE LOCATIONS OF PUBLIC OYSTER REEFS AND PRIVATE OYSTER LEASES
ENGINEER NEW ORLEANS
CORPS OF ENGINEERS
NO
SCALE OF MILES
5 0 5 10

PLATE A-6


LOUISIANA COASTAL ZONE
LAND CHANGE RATES 1955-1978
legend
ac mi2 /yr
LOSS
very severe (>4)
severe (2-4)
moderate (1-2)
low (0-1
GAIN
miles
0
25
50
kilometers
Coastal Zone Boundary
Sabine River
Calcasieu River
LAKE CHARLES
Mermentau River
LAFAYETTE
Vermilion River
Atchafalaya River
BATON ROUGE
Mississippi River
NEW ORLEANS
B Lafourche
Pearl River
Gulf
Of
Mexico
COASTAL ENVIRONMENTS, INC.
PLATE A 7


LIMIT OF STUDY AREA
INLAND LIMIT OF COASTAL MARSHES
FRESH
NON FRESH
BRACKISH SALINE BOUNDARY
LA
MS
MS
AL
LAKE PONTCHARTRAIN
MISSISSIPPI RIVER
LAKE BORGNE
STUDY AREA
GULF OF MEXICO
0
25
miles
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS
BOUNDARIES BETWEEN FRESH AND NON-FRESH MARSHES IN THE 1950'S
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS, LA
CORPS OF ENGINEERS
APRIL 1984
FILE NO.
PLATE A-8



BOUNDARIES BETWEEN FRESH
AND NON-FRESH MARSHES
IN THE 1950'S

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS, LA
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

PLATE A-8

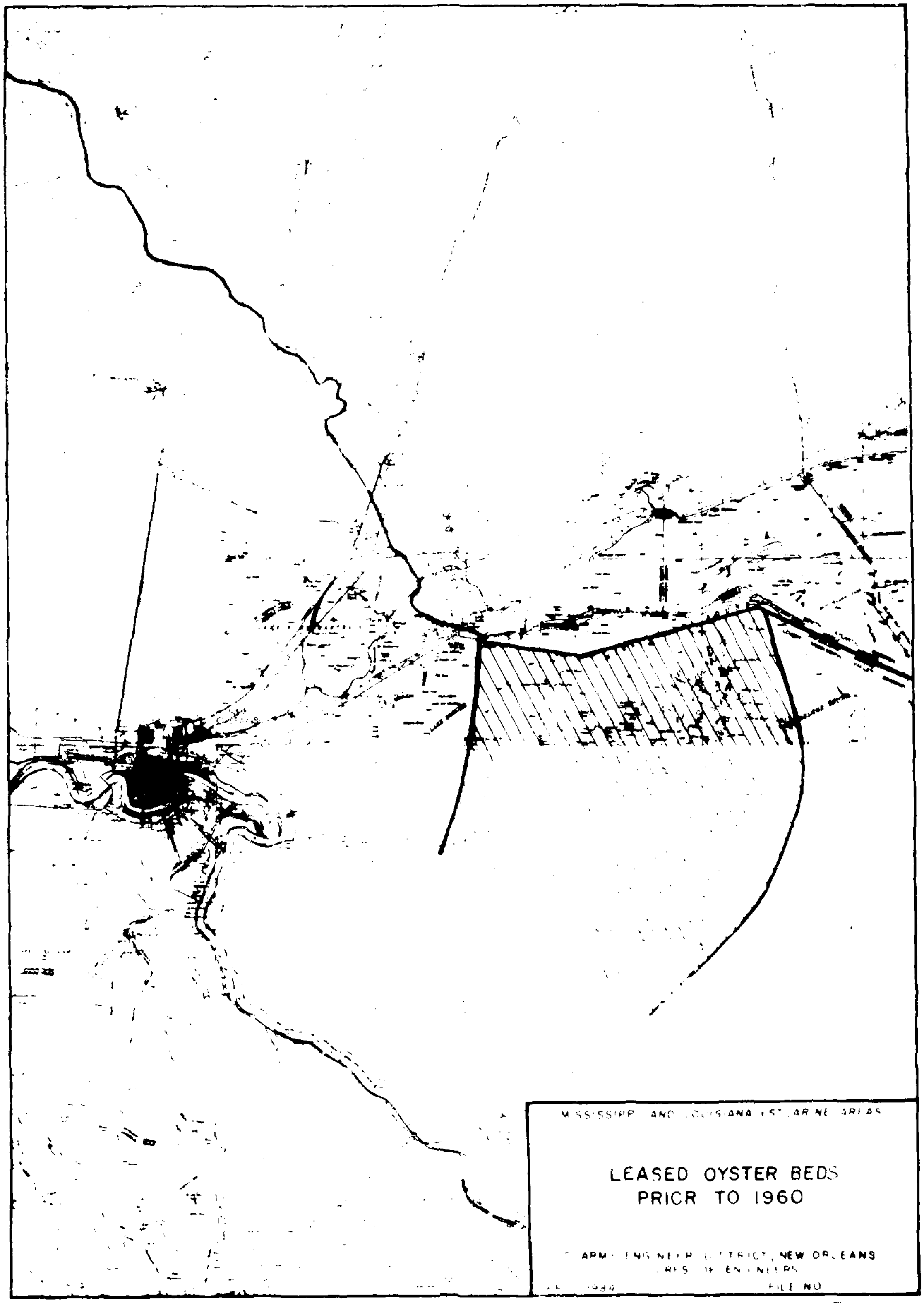


PLATE A-9

TABLE B-1-1 (CONTINUED)

CONCEPTUAL ALTERNATIVE PLANS

Alternative Plan	Plan Description
10	Construct system of saltwater barriers and weirs in marshes.
11	Construct artificial barrier islands and reefs connecting existing islands.
12	Regulate alteration and destruction of wetlands.
13	Fill subsiding areas.
14	Establish sanctuaries in areas important as breeding, nursery, and feeding grounds.
15	Manage fish and wildlife by regulating harvest, stocking, planting of cultch and vegetation, and controlled burning of marshes.
16	Various combinations of above.
17	No action.

TABLE B-1-1

CONCEPTUAL ALTERNATIVE PLANS

Alternative Plan	Plan Description
1	Divert fresh water from Mississippi River at one location above New Orleans.
2	Divert fresh water from Mississippi River at one location below New Orleans.
3	Divert fresh water from Mississippi River at one location above New Orleans and at one location below New Orleans.
4	Divert fresh water from Mississippi River at most effective combination of sites above New Orleans.
5	Divert fresh water from Mississippi River at most effective combination of sites below New Orleans.
6	Divert fresh water from Mississippi River at most effective combination of sites above and below New Orleans.
7	Divert fresh water from Mississippi River at Bayous Manchac, Braud, and Conway, Blind River, drainage canals at Garyville, Reserve Relief Canal, canals north of boundary of Bonnet Carre' Spillway, canals inside Bonnet Carre' Spillway, Walker Canal St. Charles Parish Canal, Inner Harbor Navigation Canal, Lake Borgne Canal, and Bayous Terre Aux Boeufs and La Loutre.
8	Divert fresh water from Mississippi River using siphons at above locations.
9	Construct navigable saltwater barrier in Mississippi River-Gulf Outlet.

• Divert fresh water. The former Mississippi River overflow regime could be simulated by diverting river water with its sediment and nutrients into the adjacent marshes and estuaries. The diversion could be accomplished by placing gravity flow control structures in the Mississippi River levee and by dredging a training channel to the receiving water body. Other methods include siphons or pumping stations that would lift the required flow over the Mississippi River mainline flood control levee. The structure or pumping station would be operated according to the need for supplemental fresh water to enhance habitat conditions of fish and wildlife species using the area and as stages in the river and tailwater areas permit.

PLAN FORMULATION RATIONALE

PRELIMINARY STAGE ANALYSIS

B.1.4. In the reconnaissance phase of the study, the plan formulation process was initiated by identifying structural and nonstructural measures that would make contributions to the planning objectives. The measures were used to formulate 16 conceptual alternative plans. The no-action alternative plan was also considered. The 17 plans include eight plans to divert fresh water, three barrier plans, a plan to regulate alteration of wetlands, a plan to fill subsiding areas, a plan to establish sanctuaries, a plan to manage fish and wildlife, a plan that includes several of the measures, and the no-action plan. The 17 conceptual plans are described in table B-1-1. The alternate plans were assessed and evaluated during the reconnaissance phase and eight plans were eliminated. The plans were eliminated because they were either too costly, caused unacceptable environmental damage, interfered with navigation, or caused severe impacts on development in urbanizing areas. Table B-1-2 identifies the plans eliminated and summarizes the reasons for elimination. The assessment and evaluation of the 17 plans are documented in the reconnaissance report for the study dated July 1981. In the report, it was determined that the nine conceptual plans

[illegible] Stocking programs can [illegible] certain fish and wildlife [illegible] can also be studied. Planting [illegible] substrate for attachment of oyster [illegible] growing stage has been done for many [illegible].

[illegible] structures is beneficial for [illegible] commercially and recreationally important fish. [illegible] ridges would provide habitat for many [illegible]. This habitat type is very valuable and is rapidly [illegible] result of residential construction and industrial uses [illegible].

[illegible] certain species of vegetation provide [illegible] for [illegible] wildlife species and serve to reduce land [illegible] burning of marshes during mid- to late winter serves [illegible] marsh vegetation and release nutrients that [illegible] growth the following spring and summer. The [illegible] of vegetation provides food and cover for waterfowl and [illegible] the biomass of vegetation that provides a source of detritus important to fishery resources.

- Saltwater barriers. Saltwater intrusion could be retarded by placing [illegible] barriers in major canals. The barriers would remain [illegible] fish migrations, but would be closed during periods of low [illegible] inflows and high tides in the gulf. Saltwater inflows could be further reduced using weirs and artificial barrier islands. A combination of artificial barrier islands, weirs, and saltwater barriers would reduce the amount of fresh water required to alter the existing salinity gradients and would help retain fresh water in the marshes. The barriers would be designed to pass the flood of record.

Section 1. FORMULATION OF ALTERNATIVE PLANS

MANAGEMENT MEASURES

B.1.1. In the reconnaissance stage of plan formulation, a broad range of measures that could address one or more of the planning objectives presented in Appendix A was identified. Some measures were suggested by individuals at public meetings on February 1 and 9, 1978. Some were suggested by state and local agencies and others were identified by the US Army Corps of Engineers. The measures are:

- Regulate alteration of wetlands. Regulating activities that alter the wetlands would aid in preserving and maintaining the area for fish and wildlife.

- Fill water areas. Dredged material obtained during maintenance dredging of navigation projects in the area could be used to fill subsiding areas.

- Establish sanctuaries. Critical and unique fish and wildlife breeding, nursery, and feeding grounds could be preserved by establishing sanctuaries.

- Manage fish and wildlife. Fish and wildlife productivity could be improved by such management practices as regulating harvests, stocking programs, planting cultch material for oysters, planting vegetation, and controlled marsh burning. Harvest regulations could include controlled harvest seasons to protect various fish and wildlife species during critical stages in their life cycles, creel and bag limits to prevent overharvest of fish and wildlife species, size limits to prevent the taking of certain species before sexual maturity, restrictions on taking females, and restrictions on harvesting gear to prevent

MISSISSIPPI AND LOUISIANA ESTUARINE AREAS STUDY

Report on Freshwater Diversion

to the

Lake Pontchartrain Basin and Mississippi Sound

Appendix B

F O R M U L A T I O N, A S S E S S M E N T, A N D E V A L U A T I O N O F D E T A I L E D P L A N S

B.0.1. In this appendix, the process of formulating alternative plans and the rationale for plan selection is described. In Section 1, management measures are evaluated and the most feasible measures are incorporated into an array of conceptual and specific plans. Analysis of the freshwater diversion plans retained for further study is presented in Section 2. The sites are evaluated in terms of engineering performance and feasibility and adverse and beneficial effects. The evaluation and trade-off analysis are discussed and impacts are given. The rationale for the recommended plan is presented. The recommended plan is described and implementation responsibilities identified in Section 3.

LIST OF PLATES

LIST OF EXHIBITS

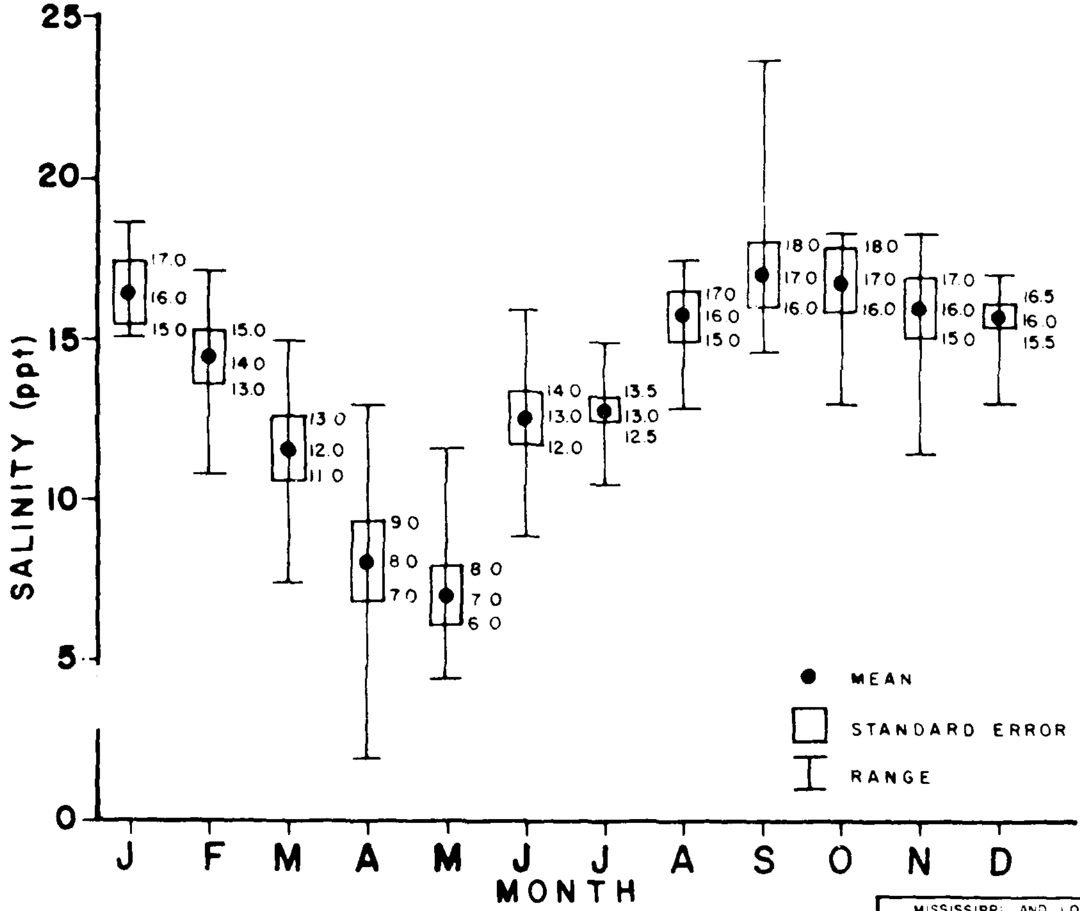
LIST OF TABLES

TABLE OF CONTENTS

TABLE OF CONTENTS

APPENDIX B

FORMULATION, ASSESSMENT, AND EVALUATION OF DETAILED PLANS



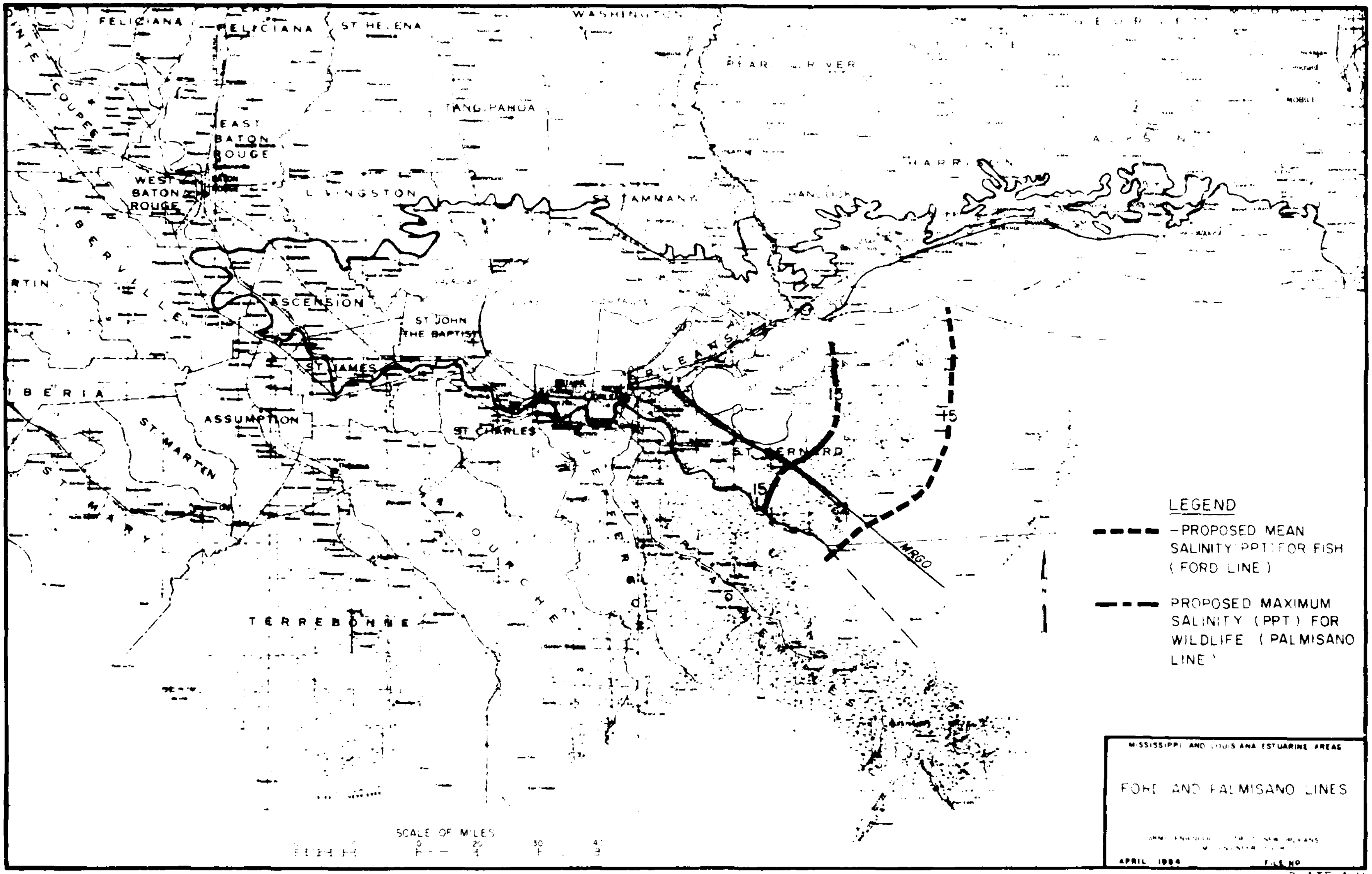
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

OPTIMUM SALINITY REGIME

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984

PLATE A-12



FELICIANA
EAST FELICIANA
ST HELENA
WASHINGTON
PEARL RIVER
TANGIPAHOA
EAST BATON ROUGE
WEST BATON ROUGE
LIVINGSTON
ST TAMMANY
HARRISON
HANCOCK
POINTE COUPEE
IBERVILLE
ASCENSION
ST JOHN THE BAPTIST
ST JAMES
ORLEANS
ST BERNARD
ST CHARLES
ASSUMPTION
IBERIA
ST MARTIN
ST MARY
LAFOURCHE
JEFFERSON
PLAQUEMINES
TERREBONNE
MRGO
15
15
5
LEGEND
-PROPOSED MEAN SALINITY (PPT) FOR FISH (FORD LINE)
PROPOSED MAXIMUM SALINITY (PPT) FOR WILDLIFE (PALMISANO LINE)
SCALE OF MILES
0
20
30
40
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS
FORD AND PALMISANO LINES
APRIL 1984
FILE NO

PLATE A-1

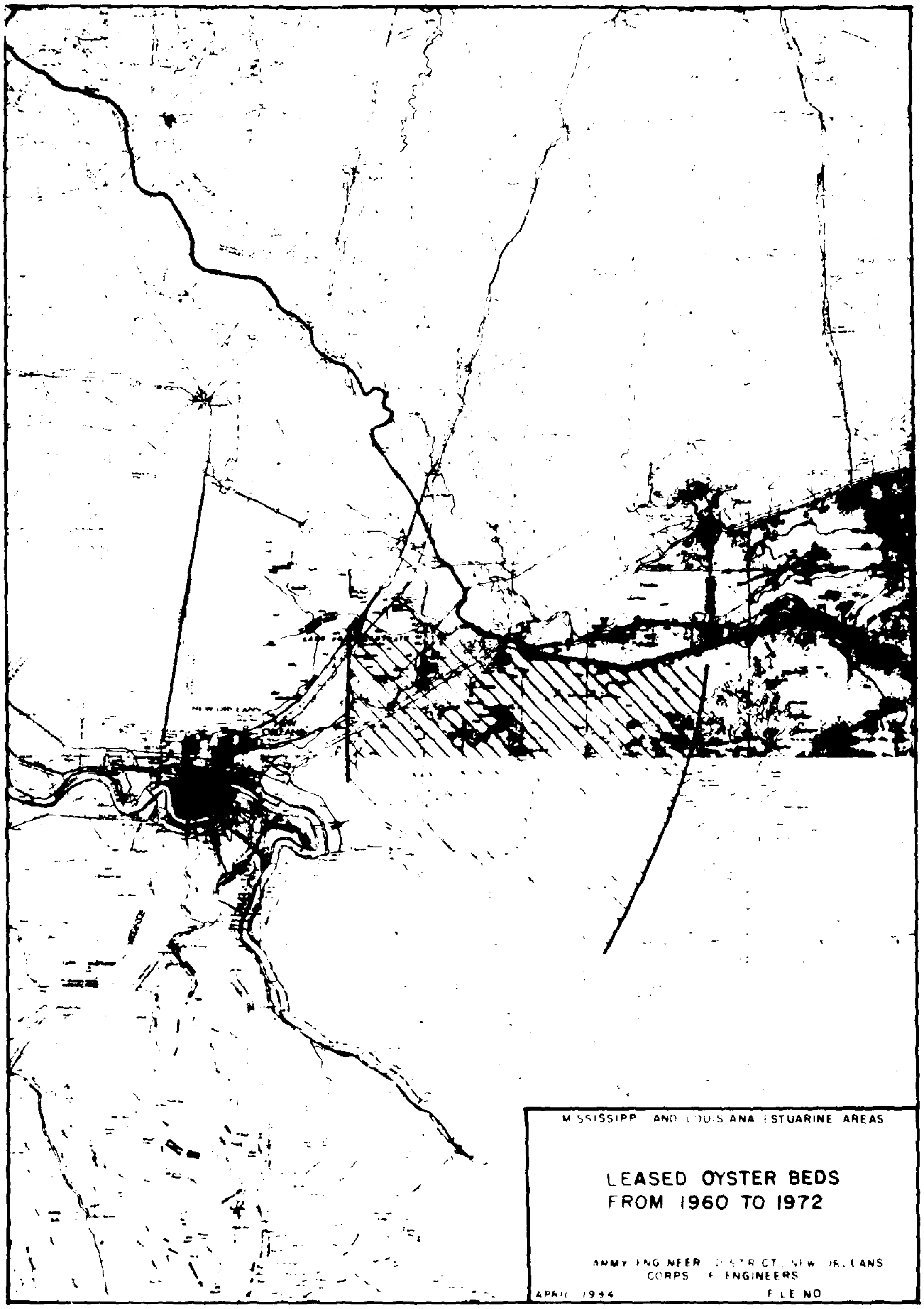

MISSISSIPPI AND LOUISIANA ESTUARINE AREAS
LEASED OYSTER BEDS
FROM 1960 TO 1972
ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
FILE NO

PLATE A-10

TABLE B-1-2

CONCEPTUAL PLANS ELIMINATED AND RATIONALE

Alternative Plan No.	Too Costly	Unacceptable Environmental Damage	Interferes With Navigation	Causes Severe Impacts To Urbanizing Areas
4	X	X		X
5	X	X		X
6	X	X		X
7	X	X	X	X
8	X	X		X
9	X		X	
10	X		X	
11	X		X	

in table B-1-3 would be subjected to further analysis. In the feasibility phase, the conceptual plans retained were further analyzed and screened to determine their contributions to the more detailed objectives identified in studies completed after the reconnaissance phase. During the screening, those plans that warranted detailed consideration were formulated into specific plans for further analysis.

ANALYSIS AND SCREENING OF CONCEPTUAL ALTERNATIVE PLANS

CONCEPTUAL ALTERNATIVES 1, 2, AND 3—FRESHWATER DIVERSION

B.1.5. Freshwater diversion is not only a specific requirement in the authorizing resolution but would also make a major contribution to enhancing vegetative growth, establishing favorable salinity gradients, and increasing sport and commercial fish and wildlife production. Diversion would provide moderate contributions to preserving and restoring wetlands, as well. As a result, the conceptual alternatives 1, 2, and 3 were retained for further analysis. Pumps, siphons, and multicell concrete box culvert were considered in the analysis as diversion control structures. Pumps were determined to be too costly. Siphons were considered impractical due to large head losses. Multicell concrete box culvert were selected because they are generally less expensive.

B.1.6. To define specific plans for analysis, a site evaluation was performed for each of the conceptual alternative plans. In the site evaluation studies, sites were identified using topographical and infra red maps, field reconnaissance, and general knowledge of the study area. Engineering, environmental, and socio-economic criteria were established to identify potential diversion sites. Under the engineering criteria the length of the route to the receiving water body, the hydraulic efficiency, the amount of channel excavation,

TABLE B-1-3

CONCEPTUAL PLANS RETAINED FOR FURTHER ANALYSIS

Conceptual Alternative Plan No.	Plan Description
1	Divert fresh water from Mississippi River at one location above New Orleans.
2	Divert fresh water from Mississippi River at one location below New Orleans.
3	Divert fresh water from Mississippi River at one location above and at one location below New Orleans.
12	Regulate alteration and destruction of wetlands.
13	Fill subsiding areas.
14	Establish sanctuaries in areas important as breeding, nursery, and fishing grounds.
15	Manage fish and wildlife by regulating harvest, stocking, planting of cultch, and vegetation, and controlled burning of marshes.
16	Various combinations of plans.
17	No action.

relocation of roads and local drainage systems, and relative cost were evaluated. How adverse impacts could be minimized by using existing waterways or how to avoid scenic rivers and special areas of biological importance were considered under the environmental criteria. Under the economic and social criteria, minimizing relocations of commercial, industrial, and residential development and institutional considerations were evaluated.

CONCEPTUAL ALTERNATIVE 1--DIVERT FRESHWATER AT ONE LOCATION ABOVE NEW ORLEANS

B.1.7. Ten potential freshwater diversion sites were identified above New Orleans: six would divert into Lake Maurepas and four would divert into Lake Pontchartrain. The 10 sites are shown on plate B-1. A site along the river above Bayou Manchac was not chosen because channel excavation to the Amite River or tributaries would be prohibitively expensive. In addition, large quantities of water added to the upper Amite River Basin during the spring when most diversions would be necessary could increase the possibilities of flood problems in East Baton Rouge, Livingston, and Ascension Parishes. No sites were located along the river between the city of Kenner and the Inner Harbor Navigation Canal (IHNC) because the extensive urban development would make such a site impractical. The 10 potential diversion sites are described below.

B.1.8. Bayou Manchac site. This site is located at mile 214.8 above the Head of Passes (AHP), about 1.5 miles south of Burtville. Water would be diverted from the Mississippi River to Bayou Manchac. The water would flow via Bayou Manchac into the Amite River, then into the Blind River and into Lake Maurepas. Approximately 40 miles of channel improvements would be required.

B.1.9. Bayou Braud site. This site is at mile 196 AHP, about 5 miles downriver of the community of St. Gabriel. A land cut diversion channel would connect the Mississippi River to Bayou Braud. The diverted water would flow through the improved bayou and thence via Amite and Blind Rivers to Lake Maurepas. A total of 45 miles of channel improvements would be required.

B.1.10. Bayou Conway site. This site is located at about mile 176 AHP on the Mississippi River, approximately 0.5 miles upriver from the community of Darrow. A land cut channel would be used to convey the water to Bayou Conway. Bayous Conway and Francois and New River and Blind River would be improved to accommodate the increased flow to Lake Maurepas. About 30 miles of channel improvements would be required.

B.1.11. Blind River site. This site is a few miles downstream from the community of Convent at mile 155 AHP. The diverted flow would be carried by a land cut channel to Bayou Des Acadiers. From the bayou, the water would flow through St. James Parish Canal and the Blind River to Lake Maurepas. About 25 miles of channel improvements would be required.

B.1.12. Garyville Canal site. This site is near mile 142 AHP, 1 mile upriver of Garyville. The proposed diversion channel would connect the Mississippi River to Hope Canal. From an improved Hope Canal, the fresh water would travel about 15 miles through Bayou Tent and Dutch Bayou before flowing into Lake Maurepas. Bayou Tent and Dutch Bayou would be enlarged to accommodate the increased flow.

B.1.13. Reserve Relief Canal site. This site is at mile 137.4 AHP adjacent to the community of Reserve. The 8.5-mile Reserve Relief Canal would be enlarged to accommodate the water diverted into Lake Maurepas.

B.1.14. Canal West of Bonnet Carre' Floodway site. This site is adjacent to the community of Montz near mile 129 AHP. A 6.4-mile diversion canal from the Mississippi River to Lake Pontchartrain would be required just west of the upper guide levee of the Bonnet Carre' Spillway. The Canal Inside of Bonnet Carre' Floodway site is at approximately the same location but the diversion channel would be located within the floodway.

B.1.15. Walker Canal site. This site is at mile 116 AHP, about 1 mile upriver of the St. Charles-Jefferson Parish line. The 5.5-mile Walker Canal would be enlarged and lengthened to accommodate the increased flow to Lake Pontchartrain.

B.1.16. St. Charles Parish Canal site. This site is at mile 115.0 AHP on the St. Charles-Jefferson Parish line. The 5.0-mile canal would be enlarged and lengthened to accommodate the increased fresh water flow.

B.1.17. To determine the most feasible site, order-of-magnitude engineering, socio-economic, and environmental assessments were made of the potential diversion sites. The engineering assessment consisted of a preliminary hydraulic design, structure and channel design, relocations, hydraulic efficiency and foundation considerations such as erosion, settling, and seepage, and structure and channel costs. The environmental and socio-economic assessments used available reports, file data, maps, infra red photography, and ground reconnaissance to appraise serious impacts on habitat types, water quality, cultural resources, businesses, residences, and existing facilities. Pertinent data from the assessment are shown in table B-1-4.

B.1.18. Assessing the comparative performances of the diversion sites based on the engineering, socio-economic, and environmental information was difficult since the information either was not quantified or was not quantified in the same units. To assist in the evaluation, a procedure

TABLE B-1-4

EVALUATION DATA ON POTENTIAL
FRESHWATER DIVERSION SITES ABOVE NEW ORLEANS

Site Name	Mile AHP	Primary Receiving Body	Parish Affected	Number of Relocations		Foundation Considerations	Length of Diversion Channel (Miles)	Habitat Altered				Relocation	Aggravate Flood Problems
								Bottomland Hardwoods	Wooded Swamps	Marshes	Other		
Bayou Manchac	214.8	Lake Maurepas	East Baton Rouge, Ascension, Livingston, St. John the Baptist	6 roads 6 pipe-lines	3 powerlines 3 bridges	SP FP EC	40	970	-	-	-	5 residents . com. bldg.	Possible
Bayou Braud	196.0	Lake Maurepas	Iberville, Livingston, Ascension, St. John the Baptist Parish	3 roads 5 pipe-lines	2 powerlines 7 bridges	SP EC SCP	45	394	364	-	-	1 com bldg.	Possible
Bayou Conway	176.0	Lake Maurepas	Ascension, St. John the Baptist	2 roads 8 pipe-lines	7 bridges	SP EC SEP EP	30	390	758	-	-	15 residents disrupt community	Possible
Drainage Canal into Blind River	153.0	Lake Maurepas	St. John the Baptist, St. James, Ascension	3 roads 6 pipe-lines	3 bridges	SEP EC EP	25	121	730	-	575*	5 residents	Possible
Canal at Gary-ville	142.0	Lake Maurepas	St. John the Baptist	1 road 5 pipe-lines	4 bridges	EP SEP EC	15	-	667	-	120*	disrupt community	Possible
Reserve Relief Canal	137.4	Lake Maurepas	St. John the Baptist	1 road 5 pipe-lines	4 bridges	SP SEP CC	8.5	364	-	-	-	40 residents, 1 com. bldg.	Possible
Canal West of Bonnet Carre' Spillway	129.0	Lake Pont-chartrain	St. Charles	1 road 5 pipe-lines	1 powerline 5 bridges	SP EP SEP EC	6.4	182	182	-	-	25 residents disrupt community	No
Borrow Channel inside Bonnet Carre' Spillway	128.5	Lake Pont-chartrain	St. Charles	4 pipe-lines	3 bridges	EP	6.6	-	-	-	364**	25 residents disrupt community	No
Walker and St. Charles Parish Canals	116.0 115.0	Lake Pont-chartrain	St. Charles, Jefferson	3 roads 2 pipe-lines	3 bridges	SP EP	5.0 5.5	-	182 91	182 242	-	1 sand mining co.	No

FP - Failure Problems
SP - Settlement Problems
EC - Earthfill Cofferdam required
CC - Cellular Cofferdam required
SCP - Scour Protection required
SEP - Seepage Problem
EP - Erosion Problem

*Agricultural lands
**Bottomland Hardwoods, Wooded Swamp, and Marshes

TABLE B-1-4 (Continued)

EVALUATION DATA ON POTENTIAL FRESHWATER DIVERSION SITES ABOVE NEW ORLEANS

Site Name	Hydraulic Head 1/ (feet)	Hydraulic Slope 2/ (feet/foot)	Water Quality Dredged	Cultural Resources
Bayou Manchac	12	0.00006	Increased turbidity, decreased water temperature in vicinity of outfall to Lake Maurepas. Copper, zinc, chromium, cadmium, mercury, fecal coliform bacteria may exceed EPA water quality criteria.	High probability of uncovering [illegible] cultural resources. Bayou Manchac served as major commercial artery during the [illegible] century and numerous historic sites are [illegible] its bank. Galvestown is located at [illegible] Bayou Manchac.
Bayou Braud	9.6	0.00004	Same as Bayou Manchac.	High probability of uncovering cultural resources. Hard Times Plantation and other structures are located at the site area.
Bayou Conway	8.6	0.00005	Same as Bayou Manchac.	High probability of uncovering cultural resources. Several historical structures are located at the site area.
Drainage Canal to Blind River	6.4	0.00005	Same as Bayou Manchac	Same as Bayou Conway.
Canal to Garyville	6.1	0.00008	Same as Bayou Manchac.	Medium probability of uncovering cultural resources. Site close to [illegible] Plantation and San Francisco Plantation, a National Register property.
Reserve Related Canal	5.8	0.0001	Same as Bayou Manchac.	Same as Bayou Conway.
Canal West of Bonnet Carre' Spillway	5.4	0.0002	Increased turbidity decreased water temperature in vicinity of outfall to Lake Pontchartrain. Copper, zinc, chromium, cadmium, mercury, and fecal coliform bacteria may exceed EPA water quality criteria.	Same as Bayou Conway.
Borrow Channel Inside Bonnet Carre' Spillway	5.3	0.0002	Same as canal west of Bonnet Carre' Spillway.	Low probability of uncovering cultural resources.
Walker and St. Charles Parish Canals	4.6	0.00015	Same as canal west of Bonnet Carre' Spillway.	High probability of uncovering cultural resources. Fairview and Patterson Plantations located near site.

1/ Hydraulic Head represents difference between stages in river and tailwater area.

2/ Hydraulic Slope represents ratio of hydraulic head to channel length.

was developed for comparing the engineering, socio-economic, and environmental information.[1] This procedure provided for a bias-free and more reliable, accurate, and consistent evaluation of potential freshwater diversion sites. A numerical system was devised to rate and rank the sites. The relative importance of the engineering, socio-economic, and environmental information was determined by assigning a weighted factor. The sum of all weighted factors equals 100. Engineering and environmental categories were each assigned a weighted factor of 40. Under the engineering category, the number of relocations, extent of foundation problems, number of miles of channel excavations, and relative cost were considered. The environmental category included acres of habitat altered, degree of water quality degradation, relative fish and wildlife resource productivity, scenic rivers and streams altered, probability of disturbing cultural resources, and improvement of fish and wildlife harvest. The highest weight (40) was given to the environmental and engineering categories because environmental enhancement is the major objective of the study, and engineering considerations were the primary factors in site selection. Socio-economic considerations were given a low rating of 20 because cost is considered as part of the engineering category and other economic considerations are significantly less. Included in the socio-economic category are relocations of residents, aesthetic considerations, and employment impacts. The engineering, environmental, and socio-economic subcategories were given a relative rating of "Major," "Moderate," or "Minor." For instance, in the relocation subcategory, diversion sites that required a large number of relocations were given a rating of "Major." "High," "Medium," or "Low" were the relative ratings used to indicate the probability that archeological or historical sites might be disturbed. "Yes" or "No" was used to indicate whether a scenic

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1/ Barish, N. N. 1962. Economic Analysis for Engineering and Managerial Decision Making.

river or stream might be affected. "Most," "Moderate," or "Least" were used to describe the relative cost. A numerical value was assigned to the relative rating as shown below:

Relative Rating	Numerical Value
Major	1
Moderate	5
Minor	10
Most	1
Moderate	5
Least	10
High	1
Medium	5
Low	10
Yes	1
No	5

B.1.19. The weighted factors were multiplied by the relative rating value, resulting in an effectiveness factor. The effectiveness factors were summed by diversion sites and the diversion sites ranked according to effectiveness factors. The relative ratings are shown in table B-1-5. If the effectiveness factor was high, the diversion site would be less costly and more effective in attaining study planning objectives, and would have minimal adverse impacts on the environment. Numerical values, resultant effectiveness factors, and ranking of the sites are shown in table B-1-6.

B.1.20. The ranking of the diversion sites is shown on plate B-2 and on table B-1-7 with supporting information. As a result of assessing the 10 potential sites above New Orleans, the borrow channel inside Bonnet Carre' Floodway site was determined to be the most feasible and a plan with this site was retained for further analysis.

CONCEPTUAL ALTERNATIVE 2—DIVERT FRESHWATER AT ONE LOCATION BELOW NEW ORLEANS

B.2.21. Three potential freshwater diversion sites were identified that primarily divert to Lake Borgne below New Orleans. The IHNC was identi-

TABLE B-1-[illegible]

RELATIVE RATINGS OF POTENTIAL FRESHWATER DIVERSION SITES ABOVE NEW ORLEANS

	Engineering				Environmental											
Site Name	Relocation	Foundation Problems	Channel Excavation	Cost	Habitat Altered	Water Quality Degraded Marine	Water Quality Degraded Freshwater	Resource Productivity Marine	Resource Productivity Freshwater	Resource Productivity Wildlife	LA Scenic River and Streams Altered	Cultural Resources Disturbed	Fish & Wildlife Harvest Commercial	Fish & Wildlife Harvest Sport	Adverse Economic & Social Impact	[illegible]
Bayou Manchac	Major	Moderate	Major	Most	Major	Minor	Moderate	Major	Moderate	Moderate	Yes	High	Major	Major	Major	Moderate
Bayou Braud	Major	Minor	Major	Most	Major	Minor	Moderate	Major	Moderate	Moderate	Yes	High	Major	Major	Major	Moderate
Bayou Conway	Major	Minor	Moderate	Most	Major	Minor	Moderate	Major	Moderate	Moderate	Yes	High	Major	Major	Major	Moderate
Drainage Canal into Blind River	Major	Minor	Moderate	Most	Major	Minor	Moderate	Major	Moderate	Moderate	Yes	High	Major	Major	Major	Moderate
Canal at Garyville	Moderate	Major	Moderate	Most	Major	Minor	Moderate	Major	Moderate	Moderate	No	Medium	Major	Major	Moderate	Major
Reserve Relief Canal	Moderate	Major	Minor	Moderate	Moderate	Minor	Moderate	Major	Moderate	Moderate	No	High	Major	Major	Major	Major
Canal West of Bonnet Carre' Spillway	Moderate	Moderate	Minor	Least	Moderate	Moderate	Minor	Major	Minor	Moderate	No	High	Major	Major	Moderate	Moderate
Borrow Channel inside Bonnet Carre' Spillway	Moderate	Minor	Minor	Least	Minor	Moderate	Minor	Major	Minor	Moderate	No	Low	Major	Major	Moderate	Moderate
Walker & St. Charles Parish Canals	Moderate	Moderate	Minor	Moderate	Minor	Moderate	Minor	Major	Minor	Moderate	No	High	Major	Major	Moderate	Major

TABLE B-1-6

EVALUATION OF POTENTIAL FRESHWATER DIVERSION SITES ABOVE NEW ORLEANS

	Engineering Rating (wt. 40)					Environmental Rating (wt. 40)												Economic and Social Rating (wt. 20)				
Site Name	Relocation	Foundation	Channel Excavation	Cost	EF*	Habitat Altered	Water Quality Degraded Marine	Water Quality Degraded Freshwater	Resource Productivity Marine	Resource Productivity Freshwater	Resource Productivity Wildlife	LA Scenic River and Streams Altered	Cultural Resources	Fish & Wildlife Commercial	Fish & Wildlife Sport	EF*	Adverse Economic & Social Impacts	Public Opposition	EF*	Total EF	Ranking
**Bayou Manchac	1	5	1	1	3	1	10	5	10	5	5	1	1	10	10	23	1	5	[illegible]	27	[illegible]
**Bayou Braud	1	10	1	1	5	1	10	5	10	5	5	1	1	10	10	23	1	5	1	29	[illegible]
**Bayou Conway	1	10	5	1	7	1	10	5	10	5	5	1	1	10	10	23	1	5	[illegible]	31	[illegible]
**Drainage Canal into Blind River	1	10	5	1	7	1	10	5	10	5	5	1	1	10	10	23	1	[illegible]	1	[illegible]	[illegible]
**Canal at Garyville	5	1	5	1	5	1	10	5	10	5	5	5	5	10	10	26	5	1	1	32	[illegible]
**Reserve Relief Canal	5	1	10	5	8	5	10	5	10	5	5	5	1	10	10	26	1	1	[illegible]	34	[illegible]
**Canal West of Bonnet Carre' Spillway	5	5	10	10	12	5	5	10	10	1	5	5	1	10	10	25	5	5	2	39	[illegible]
**Borrow Channel inside Bonnet Carre' Spillway	5	10	10	10	14	10	5	10	10	1	5	5	10	10	10	30	5	5	2	[illegible]	[illegible]
**Walker & St. Charles Parish Canal	5	5	10	5	10	10	5	10	10	1	5	5	1	10	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* Evaluation Factor
** Site located above New Orleans
*** Site located below New Orleans

TABLE B-1-7

RANKING OF POTENTIAL FRESHWATER DIVERSION SITES ABOVE NEW ORLEANS

Ranking	Site Name	Reasons
1	Borrow Channel inside Bonnet Carre' Floodway	Minimal foundation problems, channel, excavation, cost, and habitat alteration. Low probability of disturbing archeological and historical sites. Moderate relocations, adverse socio-economic impacts, and public opposition. Government-owned land in the floodway.
2	Canal West of Bonnet Carre' Floodway	Same as Borrow Channel inside Bonnet Carre' Floodway site except more foundation problems expected and more habitat would be altered.
3	Walker Canal & St. Charles Parish Canal	Moderate relocation and foundation problems, high probability of disturbing archeological and historical sites. Moderate adverse socio-economic impacts. Moderate public opposition.
4	Reserve Relief Canal	Moderate relocation and substantial foundation problems, moderate habitat alterations. Substantial adverse socio-economic impacts and public opposition.
5	Canal at Garyville	Major relocation and foundation problems. Very costly. Major habitat alteration. Moderate adverse socio-economic impacts. May aggravate flood problems.

TABLE B-1-7 (CONTINUED)

RANKING OF POTENTIAL FRESHWATER DIVERSION SITES ABOVE NEW ORLEANS

Ranking	Site Name	Reasons
6	Bayou Conway	Substantial relocations. Moderate channel excavation. Very costly. Scenic river or stream may be altered, high probability of disturbing archeological and historical sites. Substantial adverse socio-economic impacts. Moderate public opposition. May aggravate flood problems.
6	Drainage Canal into Blind River	Same as Bayou Conway site.
7	Bayou Braud	Major relocation and channel excavation. Very costly. Moderate habitat alteration. Scenic river or stream may be altered. High probability of disturbing archeological sites. Moderate public opposition. May aggravate flood problems.
8	Bayou Manchac	Major relocation and channel excavation. Moderate foundation problems. Very costly. Major habitat alteration. Scenic river or stream may be altered. High probability of disturbing archeological or historic sites. May aggravate flood problems. Moderate public opposition.

fied as a potential site because conveyance channels exist to Lakes Pontchartrain and Borgne. No sites were considered between the IHNC and Violet, Louisiana, because the extensive New Orleans metropolitan area urban development along the river would make such a site impractical. Potential freshwater diversion sites were located between the communities of Violet and Riverbend and at Bayou Terre Aux Boeufs. No sites were located below the Bayou Terre Aux Boeufs site since water diverted below that point would flow into Breton Sound Basin, which is outside the study area. The three sites are shown on plate B-1 and described below.

B.1.22. IHNC site. This site is located at Mississippi River mile 92.6 AHP. Changing lock operations to increase freshwater flows through the lock is one alternative. A freshwater diversion structure adjacent to the lock within the existing rights-of-way would be another alternative. Modifications to the lock that would increase freshwater flows without adversely affecting navigation would also be an alternative. In order not to adversely affect navigation, velocities would have to be limited to less than 3 fps. The diverted water would flow through the existing Industrial Canal to Lake Pontchartrain and through the Gulf Intracoastal Waterway and Mississippi River-Gulf Outlet (MR-GO).

B.1.23. Riverbend site. This site is located near mile 83.0 AHP between the communities of Riverbend and Violet. Water would be conveyed by a 6.0-mile diversion channel through the marshes and hurricane protection levees across the MR-GO through Lake Borgne Canal to Lake Borgne.

B.1.24. Bayou Terre Aux Boeufs and La Loutre site. This site is located about mile 82.0 AHP, adjacent to the town of Poydras. A diversion channel would be necessary from the Poydras Crevasse through Bayous Terre Aux Boeuf and La Loutre to mile 36 AHP along the MR-GO.

TABLE B-1-14

WILDLIFE MANAGEMENT AREAS IN THE STUDY AREA

Management Area	Location	Size Acres	Habitat Types
Biloxi Wildlife Management Area	Eastern St. Bernard Parish, LA	39,583	Brackish and saline marsh
Manchac Wildlife Management Area	Eastern St. John the Baptist Parish, LA	8,325	Intermediate marsh and cypress-tupelo swamp.
Pearl River Wildlife Management Area	Southeastern St. Tammany Parish, LA	26,716	Swamp along Pearl River, bottomland hardwoods and cypress-type to swamp.
Breton National Wildlife Refuge	Chandeleur Islands, St. Bernard and Plaquemines Parishes, LA	7,512	Sand beaches, low sand dunes, black mangrove thickets, salt marsh, and adjacent seagrass beds.
Mississippi Sandhill Crane National Wildlife Refuge	Jackson County, MS	12,728	Coastal savannahs and pine forest
St. Tammany Refuge	St. Tammany, Parish	1,300	Brackish marsh
Joyce Wildlife Management Area	Tangipahoa Parish	13,659	Intermediate marsh and cypress-tupelo swamp.
TOTAL		109,823	

Source: A planning aid report on the Mississippi and Louisiana Estuarine Areas study, prepared by US Fish and Wildlife Service for US Army Corps of Engineers, 1980.

TABLE B-1-13 (CONTINUED)

MANAGEMENT MEASURES FOR FISHERIES

Species	Louisiana	Mississippi
Red Drum (cont'd)	licensed according to length. Restrictions on gear used in Breton Bird Refuge. Possession limit of 50/person.	net fishermen not permitted to catch or land red drum from Sep. 15 to Nov. 15 of each year. Restrictions on use of nets, seines, and traps.

Source: US Army Corps of Engineers. 1974. Fish and Wildlife Study of the Louisiana Coastal Area and the Atchafalaya Basin Floodway.

Mississippi Department of Wildlife Conservation, Bureau of Marine Resources. 1982. A Guide to Mississippi's Saltwater Fishing Regulations.

TABLE B-1-13 (CONTINUED)

MANAGEMENT MEASURES FOR FISHERIES

Species	Louisiana	Mississippi
Menhaden (cont'd)	of-state companies. Nets and boats licensed according to size. Purse seines forbidden in inshore waters except in Breton and Chandeleur Sound.	waters by out-of-state companies. Purse seines may not be used in any bays, rivers, or bayous nor within 1 mile of the shorelines of Hancock and Harrison Counties. Purse seines may not be used to catch in excess of 5% by weight spotted seatrout, bluefish, spanish or king mackerel, dolphin, pompano, cobia, and jack crevalle. Menhaden season opens on third Monday of April and closes on firsh Friday after second Tuesday in October of each year.
Croaker	Use of trammel nets, trawls, or seines restricted in Breton Bird Refuge and portions of Lakes Borgne and Maurepas.	Use of nets, seines, and traps restricted.
Spotted Seatrout	Licenses required if fishing gear other than a simple pole, 10-inch minimum size on commercial spotted seatrout. Certain areas important to seatrout conservation closed entirely to commercial seines, nets, or trawls. Possession limit of 50/person.	12-inch size minimum in sport fishing, limit on daily catch. Purse seines may not be used to catch in excess of 5% by weight. Restrictions on use of nets, seines, and traps.
Red Drum	Licenses required if fishing gear other than a simple pole. Trammel nets and seines are	14-inch size minimum on sport fishing. Limit on daily catch. Commercial

TABLE B-1-13 (CONTINUED)

MANAGEMENT MEASURES FOR FISHERIES

Species	Louisiana	Mississippi
Shrimp (cont'd)		Hancock County. No trawling is permitted in bayous. Trawling is prohibited north of the Intracoastal Waterway after sunset of Dec. 31 except by live bait dealers. Shrimp season is officially opened by public notice at such time as the Bureau of Marine Resources has determined that the shrimp have reached a legal size of greater than 68 count.
Crabs	Female crabs carrying eggs returned to waters. Hard-shell and soft-shell crabs have 5 1/2 inch size limits. Taking crabs by trawling in inshore waters during closed shrimp trawling season is unlawful.	Crabs may be taken by traditional methods such as hardline, drop net, dip net, and crab pot or trap. Crabs may be taken by trawl; however, the trawl must not exceed maximum allowable dimensions specified for shrimping. All sponge crabs (egg-bearing) caught south of the Intracoastal Waterway between the Gulfport Ship Channel and the Mississippi-Alabama state line must be immediately returned to the water.
Menhaden	Reciprocal aggrement with Texas and Mississippi governing taking of menhaden in Louisiana waters by out-	Reciprocal agreement with Louisiana and Mississippi governing the taking of menhaden in Mississippi

TABLE B-1-13

MANAGEMENT MEASURES FOR FISHERIES

Species	Louisiana	Mississippi
Oyster	Seed grounds maintained for use and benefit of oyster industry and public. Favorable cultch material planted to enhance seed production. Time, quantity, and method [illegible]rvesting oysters fro[illegible]d grounds restricted. [illegible]eshwater diversion structures have been constructed at Bayou Lamoque, Little Coquille, Bohemia, and White Ditch.	Oysters may be taken only in waters approved by the State Board of Health. Size of oyster dredge for commercial oystering limited. Favorable cultch material planted to enhance seed production. Commission on Wildlife Conservation regulates season and publishes notice of season opening and closing in local newspapers. Oysters taken must be at least 3 inches unless otherwise indicated on public notice.
Shrimp	Inshore waters opened to shrimp trawling each year based on determination of suitable stock by biologists of the Louisiana Department of Wildlife and Fisheries. Licensing may be required depending on size of boat and trawl.	Shrimp may be taken in any manner south of a line formed by the barrier islands. North of this line within the Mississippi Sound, shrimp may only be taken with a net measuring no larger than 50 feet along its cork line and 60 feet along its lead line. Trawling is not permitted in any area within 1/2 mile of the mainland nor within any bay except by licensed live bait dealers. However, trawling is permitted in the pipeline canal in

use of dredged materials to build marsh in the Louisiana portion of the study area will be investigated as part of the Louisiana Coastal Area study. The marsh creation study was initiated in FY 84.

CONCEPTUAL ALTERNATIVE 14—ESTABLISH SANCTUARIES

B.1.33. Establishing sanctuaries in important breeding, nursery, and feeding grounds would make a minor contribution to preserving wetlands and increasing fish and wildlife production. The plan would have no effect on enhancing vegetative growth or creating favorable salinity gradients. Sanctuaries protect fish and wildlife species by preserving habitat and protecting organisms during critical life cycle stages. Such protection increases productivity and reduces mortality. Louisiana inshore waters and the Mississippi Sound north of the barrier islands are managed a portion of the year as "quasi-sanctuaries" to allow certain commercially important estuarine species the opportunity to mature (see table B-1-13). This plan does not address the major problems associated with habitat losses. The plan would also reduce the commercial and sport harvest of the fish and wildlife resources. Because other plans would accomplish the planning objectives more extensively and without reducing harvest, this plan was not considered further.

CONCEPTUAL ALTERNATIVE 15—MANAGE FISH AND WILDLIFE

B.1.34. Louisiana and Mississippi have established fish and wildlife management programs. Fisheries management programs for the major commercial species are shown in table B-1-13. The management programs are primarily directed at regulating commerical harvest.

B.1.35. Six wildlife management areas, approximately 109,823 acres or about 10.5 percent of theland in the study area, have been established to enhance wildlife productivity. The wildlife management areas are described in table B-1-14.

TABLE B-1-12

STUDY AREA COASTAL ZONE MANAGEMENT PROGRAMS

Status Report

Parish/County	Status
Mississippi	
Hancock Harrison Jackson	Program report complete. Program implemented: September 1980
Louisiana	
Livingston	Draft program report in preparation
Jefferson	Final program report under reivew--DNR
St. Bernard	Final program report under review--DNR
St. Charles	Draft program report submitted to DNR August 1983 and under review
St. James	Final program report under review
St. John	Not participating in CZM program
St. Tammany	Final program report under review--DNR
Orleans	Final program report under review--DNR
Tangipahoa	Final program report in preparation

B.1.30. The State of Louisiana has an approved coastal resources program. The program contains a comprehensive set of coastal zone management policies and an organized state and local government structure for implementing the policies and delineating the coastal zone boundary. Included in the state policies are a set of coastal use guidelines that, in effect, constitute a major regulatory program for the study area. Details of the state program are in the document entitled "Louisiana Coastal Resources Program Final Environmental Impact Statement" published by the Louisiana Department of Natural Resources, dated 1980. The status of parish and county coastal zone management programs is shown in table B-1-12.

B.1.31. The regulatory programs of the Federal, state, and local governments are comprehensive and capable of effectively regulating alterations that contribute to adverse changes in the area's resources. The studies performed for this report could not identify any additional regulatory requirements that would significantly improve these programs. Stringent enforcement of the existing regulatory programs will provide a moderate contribution to meeting study planning objectives.

CONCEPTUAL ALTERNATIVE 13—FILL SUBSIDING AREAS

B.1.32. Filling open water areas with dredged material from maintenance dredging of navigation projects would provide moderate contributions to restoring wetlands, enhancing vegetative growth, and increasing wildlife production, and a minor contribution to creating favorable salinity gradients. The Corps of Engineers is using dredged material from the MR-GO to a limited extent in St. Bernard Parish to build marsh at the lower end of the waterway. In the future, more of the dredged material is expected to be used in the parish to build marsh. In addition, the

was selected because such a distribution would provide near equivalent flows at both sites. Since the analysis of individual sites showed that the IHNC site has the most favorable rating but may not be capable of providing sufficient flow without adversely affecting navigation, a combination of maximum flows through the IHNC site and the remainder of the required flows at the Bonnet Carre' site was selected.

CONCEPTUAL ALTERNATIVE 12—REGULATE ALTERATION OF WETLANDS

B.1.28. The alteration of coastal wetlands that accompanies human activities has contributed significantly to saltwater intrusion and other environmental problems. As a result, regulating adverse alterations is recognized as a means of protecting and preserving the environment. Federal, state, and local agencies have implemented programs that protect the public interest through regulation.

B.1.29. The US Army Corps of Engineers administers a major regulatory program under authorities in Sections 9, 10, and 13 of River and Harbor Act of 1899, Section 404 of the Clean Water Act of 1977, and Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972, as amended. Permits issued by the Corps are required for work on structures in navigable waters of the United States, for the discharge of dredged material or fill into navigable waters, and for transportation of dredged material for the purpose of dumping into ocean waters. Structures such as piers, wharfs, and docks, and activities that include channel excavation, placement of riprap, groins, buoys, mooring devices, cables, and pipes require permits. The Corps of Engineers revised its dredge and fill regulations in July 1975 to include nontidal wetlands and a variety of navigable waters. Coastal wetlands contiguous or adjacent to coastal waters and freshwater wetlands contigious or adjacent to primary tributaries were added to the Corps jurisdiction in 1976.

TABLE B-1-11

RANKING OF POTENTIAL FRESHWATER DIVERSION SITES BELOW NEW ORLEANS

Ranking	Site Name	Reasons
1	IHNC	No relocation, channel excavation, habitat alteration. Minimal foundation problem, low probability of disturbing archeological and historical sites. Minor adverse socio-economic impacts, widespread public support. No land acquisition required.
2	Riverbend	Major foundation problems. Very costly. Moderate habitat alteration. Scenic river or stream may be altered. High probability of disturbing archeological and historic sites. Strong public opposition.
3	Bayou Terre Aux Boeufs and La Loutre	Major foundation problems. Moderate channel excavation. Very costly. Major habitat alteration. Scenic river or stream may be altered. High probability of disturbing archeological or historic sites. Major adverse socio-economic impacts. Strong public opposition.

TABLE B-1-9

RELATIVE RATINGS OF POTENTIAL FRESHWATER DIVERSION SITES BELOW NEW ORLEANS

Site Name	Engineering				Environmental											Economic and Social	
	Relocation	Foundation Problems	Channel Excavation	Cost	Habitat Altered	Water Quality Degraded		Resource Productivity			Louisiana Scenic River and Streams Altered	Probability of Culture Resources Disturbed	Fish & Wildlife Harvest Improved		Adverse Economic and Social Impacts	Public Opposition
						Marine	Freshwater	Marine	Freshwater	Wildlife			Commercial	Sport		
Inner Harbor Navigation Canal	Minor	Minor	Minor	Least	Minor	Moderate	Minor	Major	Minor	Moderate	No	Low	Major	Major	Minor	Minor
Riverbend	Moderate	Major	Minor	Most	Moderate	Moderate	Minor	Major	Minor	Moderate	Yes	High	Major	Major	Moderate	Major
Bayou Terre Aux Boeufs and La Loutre	Moderate	Major	Moderate	Most	Major	Moderate	Minor	Major	Minor	Moderate	Yes	High	Major	Major	Major	Major

TABLE B-1-10

EVALUATION OF POTENTIAL FRESHWATER DIVERSION SITES BELOW NEW ORLEANS

Site Name	Engineering Rating (wt. 40)					Environmental Rating (wt. 40)												Economic and Social Rating (wt. 20)				
	Relocation	Foundation	Channel Excavation	Cost	EF*	Habitat Altered	Water Quality Degraded		Resource Productivity			LA Scenic River and Streams Altered	Cultural Resources	Fish & Wildlife		EF*	Adverse Economic & Social Impacts	Public Opposition	EF*	Total EF	Ranking
							Marine	Freshwater	Marine	Freshwater	Wildlife			Commercial	Sport						
**Inner Harbor Navigation Canal	10	10	10	10	16	[illegible]	5	[illegible]	[illegible]	1	5	5	10	10	10	30	10	10	4	50	1
***Riverbend	5	1	[illegible]	[illegible]	[illegible]	5	5	10	1	1	5	1	1	10	10	23	5	1	1	31	[illegible]
***Bayou Terre Aux Boeuf and La Loutre	5	1	5	[illegible]	[illegible]	1	5	10	1	1	5	1	1	10	10	21	1	1	[illegible]	26	[illegible]

*Evaluation Factor

**Site located above New Orleans

***Site located below New Orleans

[illegible]

EVALUATION DATA ON POTENTIAL
FRESHWATER DIVERSION SITES BELOW NEW ORLEANS

Site Name	Mile AHP	Primary Receiving Body	Parish Affected	Number of Relocations	Foundation Considerations	Length of Diversion Channel (Miles)	Habitat Affected: Bottomland Hardwoods	Wooded Swamps	[illegible]	[illegible]	[illegible]	[illegible]
Inner Harbor Navigation Canal	92.6	Lake Borgne/ Lake Pont-chartrain	Orleans		-	5.5	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Riverbend	83.0	Lake Borgne	St. Bernard	2 roads 5 pipelines	SP SEP EP	6	61	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Bayou Terre Aux Boeuf and La Loutre	82.0	Chandeleur Sound	St. Bernard	2 roads 3 pipelines	EP SEP SP EC	26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

FP - Failure Problems
SP - Settlement Problems
EC - Earthfill Cofferdam required
CC - Cellular Cofferdam required
SCP- Scour Protection required
SEP- Seepage Problem
EP - Erosion Problem

*Agricultural lands
**Bottomland Hardwoods, Wooded Swamp, and Marshes

TABLE B-1-8

EVALUATION DATA ON POTENTIAL FRESHWATER DIVERSION SITES BELOW NEW ORLEANS

Site Name	Hydraulic Head[1/] (feet)	Hydraulic Slope[2/] (feet/foot)	Water Quality Dredged	Cultural Resources
IHNC	3.4	0.00010	Increased turbidity decreased water temperature in vicinity of outfall to Lake Pontchartrain. Copper, zinc, chromium, cadmium, mercury, and fecal coliform bacteria may exceed EPA water quality criteria. Lead and arsenic may occasionally exceed EPA water quality criteria.	Low probability of uncovering cultural resources.
Riverbend	3.1	0.00010	Same as IHNC.	High probability of uncovering cultural resources. Hard Times Plantation and other structures are located at the site area.
Bayou Terre Aux, Boeuf and La Loutre	3.0	0.00003	Same as IHNC.	Same as Riverbend.

1/ Hydraulic Head represents difference between stages in river and tailwater area.

2/ Hydraulic Slope represents ratio of hydraulic head to channel length.

The channel would extend about 20 miles from the Mississippi River to the MR-GO.

B.1.25. Order-of-magnitude engineering, socio-economic, and environmental assessments were made of these potential sites similar to those made for the sites above New Orleans. Pertinent data from the assessment are shown in table B-1-8. The same numerical relative rating system was employed in the assessment. The relative ratings for these sites are shown in table B-1-9 and the numerical values, resultant effectiveness factors, and ranking of the sites are shown in table B-1-10. The ranking of the sites with supporting information are shown on plate B-2 and on table B-1-11.

B.1.26. Although the IHNC site ranks better than the other two sites, both the IHNC site and the Riverbend site were retained. The Riverbend site was retained because preliminary analysis indicated that it may not be possible to divert sufficient flow through the IHNC site without adversely affecting navigation. As a result, two plans to divert fresh water to Lake Borgne below New Orleans were retained for further analysis.

CONCEPTUAL ATERNATIVE 3—DIVERT FRESHWATER AT ONE LOCATION ABOVE AND ONE LOCATION BELOW NEW ORLEANS

B.1.27. Diverting fresh water at two locations, one above and one below New Orleans, is an attempt to balance the advantages and disadvantages of using only one site. Since three plans with single sites were retained for detailed analysis, the three sites were used to develop combination plans. Diverting 50 percent of the required flow at both the Bonnet Carre' site and the Riverbend site was selected. Diverting 75 percent of the required flow at the Bonnet Carre' site and 25 percent at the Riverbend site was also selected. The 75-25 percent distribution

B.1.36. Managing fish and wildlife populations by regulating harvest, stocking programs, planting clutch material for oyster culture, planting and propagating vegetation, and by controlled marsh burning would make a minor contribution to enhancing vegetative growth, and moderate contributions to increasing fish and wildlife production. The Louisiana Department of Wildlife and Fisheries plants cultch material for oyster culture on public oyster seed grounds. Funds for planting cultch material are obtained from the Coastal Energy Impact Program. Decisions on where to plant cultch is made by Department of Wildlife and Fisheries biologists. In the study area, cultch material was planted in Bay Boudreau, Half Moon Island, and Le Petit Pass throughout the late 1960s and early 1970s. In 1979, approximately 1,000 acres of cultch material was planted in Bay Boudreau and about 400 acres in Le Petit Pass. About 500 acres of cultch material will be planted in the study area in 1984. The plantings mostly occurred the same year the Bonnet Carre' Spillway was opened. A good oyster spat set resulted and oyster production has been fairly successful in subsequent years when favorable salinities existed. In recent years the Department of Wildlife and Fisheries has concentrated cultch planting in the Breton Sound Basin, the location of the most productive public seed grounds. Cultch material was planted in the Black Bay area in 1981. About 100 acres of material were planted in Hackberry Bay in Barataria Basin in 1981. Indications are that if favorable salinity conditions existed more often on public oyster grounds in the St. Bernard marshes and adjacent areas, the Department of Wildlife and Fisheries would expand cultch planting in the study area. Oyster fishermen have planted cultch material in leased areas where favorable salinity conditions exist most of the time. Suitable water bottoms have been created in a large portion of Lake Borgne, the most productive oyster harvesting area in the Louisiana portion of the study area.

B.1.37. In Mississippi, the Mississippi Bureau of Marine Resources initiated an Oyster Reef Rehabilitation Program on 20 August 1979. Prior to this program, oyster production in Mississippi Sound waters had declined sharply due to adverse salinity conditions, closure of reefs as a result of pollution, and adverse effects of periodic hurricanes and other tropical disturbances. Between 1960 and 1982, approximately 243,000 cubic yards of shells were planted in Mississippi waters. In recent years, most of the cultch material has been planted in western Mississippi Sound east of Cat Island. During the period September 1979 to June 1980, 87,000 cubic yards of cultch were planted in Mississippi Sound; 81,000 acres (93 percent) in the western Sound. The planting of cultch material in Mississippi Sound has significantly contributed to increased oyster production when favorable salinity conditions exist.

B.1.38. Planting and propagation of vegetation is used to a limited extent in the study area, primarily on the barrier islands in Chandeleur Sound. Controlled marsh burning is a management tool used to propagate the growth of three-cornered grass, the preferred food of muskrats. Controlled marsh burning has been used to some extent in St. Bernard Parish around Lake Lery on the Delacroix Corporation lands. The plan would have a minor effect on preserving and restoring wetlands or creating favorable salinity gradients. The plan does not create favorable salinity gradients and would make only minor contributions to the planning objectives. Because of the extensive Federal and state management programs that already exist, additional programs are not warranted until salinity, water quality, and land loss conditions improve. With improved conditions, state and local agencies would expand their current programs to maximize fish and wildlife production.

CONCEPTUAL ALTERNATIVE 16--VARIOUS COMBINATIONS OF PLANS

B.1.39. The analysis conducted for the individual conceptual plans revealed that various combinations of plans need not be considered because most of the plans are being implemented to the maximum extent practicable. Regulating alteration of wetlands is being adequately accomplished by the Federal and state permit programs and coastal zone management programs. Subsiding areas are being filled to a limited extent by the Corps of Engineers as part of the navigation maintenance program. Marsh creation studies to investigate more extensive use of dredged material as fill in subsiding areas began in FY 84. Although no sanctuaries are designated in the study area, Louisiana inshore waters and the Mississippi Sound is managed part of the year as "quasi-sanctuaries." Designating areas in the study area as sanctuaries would reduce commercial and sport harvest, which is not desirable. Programs to manage fish and wildlife resources appear to be adequate although there may be areas where these programs could be expanded.

CONCEPTUAL ALTERNATIVE 17--NO ACTION

B.1.40. If no action is taken, coastal wetlands will continue to be lost as a result of natural processes such as subsidence, compaction, and erosion, as well as human activities. Seasonal high salinities will continue to encroach upon the area and steadily reduce the extent of low salinity estuarine nursery areas, converting the fresh-intermediate-brackish marshes to more saline types. The loss of wetlands and alteration of habitat types will reduce quantity of fish and wildlife resources. The no-action alternative will serve as the base condition for comparing the merits of the other alternative plans.

SPECIFIC PLANS SELECTED FOR INTERMEDIATE STAGE ANALYSIS

B.1.41. As a result of screening the conceptual alternative plans, six specific plans were identified for intermediate analysis. All of the plans provide for diversion of Mississippi River water to the Lake Pontchartrain Basin and Mississippi Sound. The six specific plans were designated plans A through F and are shown in table B-1-15 and on plate B-3.

B.1.42. Concurrently with the analysis of the six plans, a recreation development plan was being developed. Potential recreation sites in the study area were visited and evaluated on the basis of proximity of location to the project affected areas, reasonableness of land acquisition costs, lack of or overuse of available access areas, expressed public desire for additional boating as reflected in opinion surveys, and in the recreation demand-need analysis. Detailed information on the recreation analysis is contained in Appendix G, Recreation Resources. Six recreation sites are proposed for development. They are Frenier Beach, lake end of the borrow channel within the floodway, the Rigolets, and Pointe Aux Herbes in Louisiana; and at Cedar Point and Wolf River in Mississippi. The recreation site development plan will be part of the recommended plan. Comments from the Federal, state, and local agency reviews of the proposed recreation development plan were very favorable. Requests from St. Tammany, St. Bernard, and St. Charles Parishes for additional facilities will be considered in the advanced engineering and design phase of the study. Detailed information on the recreation analysis is contained in Volume III, Appendix G, Recreation Resources.

TABLE B-1-15

SPECIFIC PLANS SELECTED FOR INTERMEDIATE STAGE ANALYSIS

Alternative Plan Number	Strategy	Diversion Site
A	Divert at one location below New Orleans	Riverbend
B	Divert at one location above New Orleans and one location below New Orleans	Bonnet Carre' - 75% of supplemental flow Riverbend - 25% of supplemental flow
C	Divert at one location above New Orleans and one location below New Orleans	Bonnet Carre' - 50 % of supplemental flow Riverbend - 50 % of supplemental flow
D	Divert at one location in New Orleans	IHNC
E	Divert at one location above New Orleans and one location in New Orleans	Bonnet Carre' IHNC
F	Divert at one location above New Orleans	Bonnet Carre'

Section 2. PRESENTATION AND EVALUATION OF PLANS

CRITERIA

B.2.1. The nature of the study objectives, primarily the objective of enhancing fish and wildlife resources, required that specific conditions be established as a basis for detailed design of the alternative plans. The optimum seasonal salinity regime for resource productivity was determined by an interagency ad hoc group in 1982. This regime was further translated into estimates of supplemental freshwater flows required to achieve the optimum salinity gradients. The seasonal supplemental flow requirements provided the basis for scoping and designing the plans. With the flow requirements, it was possible to evaluate the capability of the specific plans to meet the optimum salinity gradients and the cost effectiveness. When a specific plan did not achieve desired salinity regime or meet the performance criteria established in the Economic and Environmental Principles and Guidelines for water and related land resources implementation studies dated March 10, 1983, it was eliminated from further consideration. The performance criteria are completeness, effectiveness, efficiency, and acceptability and are defined below:

- o Completeness - the extent to which an alternative provides and accounts for all necessary investments.

- o Effectiveness - the extent to which an alternative plan is technically feasible and alleviates the identified problems.

- o Efficiency - the extent to which an alternative plan is the most cost effective means of alleviating the problems identified and is consistent with protecting the nation's environment.

o Acceptability - the workability of the alternative plan with respect to acceptance by state and local entities and the public.

[illegible].2.2. The conclusions and recommendations of the ad hoc group regarding the optimum salinity regime are in the signed Memorandum For Record and summaries of the group meetings presented in Exhibit 1. The salinity regime is shown in plate B-4. Based on a 10-year study by the Louisiana Department of Wildlife and Fisheries, the salinity regime is necessary 5 out of 10 years to produce optimum conditions for oyster production. The supplemental flows required to achieve the desired conditions were assessed at three locations in the study area. The three locations are shown on plate B-5. In the assessment, the desired conditions were determined to already exist at Location #1 most of the time. To achieve the condition at Location #3, an estimated peak diversion of 180,000 cfs to Lakes Maurepas or Pontchartrain or 225,000 cfs at or below the IHNC are required. Some supplemental flows are required throughout the period January to November to achieve the conditions. The magnitude of these peak diversions for desired conditions at Location #3 approach the capacity of Bonnet Carre' Spillway. They would require extensive modification of the IHNC, cause considerable relocation of people, and interfere with navigation in the IHNC. In addition, such diversions would be infeasible during average flow conditions on the Mississippi River of 463,000 cfs because of adverse affects on river navigation and the use of the river as a water supply source. The estimated cost of a project to accomplish such diversions would be in excess of $200 million and would far exceed the benefits generated by the diversion. Therefore, optimum salinity conditions at Location #3 were eliminated as a criteria. The assessment showed that the desired salinity regime at Location #2 could be achieved with a peak flow of 30,000 cfs to Lakes Maurepas or Pontchartrain or 45,000 cfs at the IHNC site or below. The diversion period would be from March through November. By achieving the optimum conditions at

Location #2, optimum salinities at Location #3 would be achieved for all months except for March, April, May, and July. Thus, the criteria for all plans is to achieve the desired salinity regime at Location #2. By designing all plans to achieve the desired salinity conditions at Location #2, the plans would also produce identical benefits. The estimated present worth value of the benefits that would accrue to any plan that achieves the desired salinity conditions is $79 million.

PLAN A (RIVERBEND SITE)

B.2.3. The supplemental flows required at the Riverbend site to achieve the desired salinity regime at Location #2 are shown in table B-2-1.

B.2.4. The site plan for the Riverbend site is shown in plate B-6. A control structure would be located at about river mile 83 AHP. The diversion channel would be excavated from the control structure through the hurricane protection back levee across the marshes to the MR-GO. Plan A would result in the conversion of about 1,240 acres of marsh to conveyance channel and disposal area. Plan A has a high probability of uncovering cultural resources and five natural and scenic streams would be altered. They are Bayou Dupre, Bashman Bayou, Terre Beau Bayou, Pirogue Bayou, and Lake Borgne Canal. Floodgates would be placed at the intersection of the diversion channel and the hurricane protection levee along the MR-GO. Hydraulic investigations of the Riverbend site determined that under design conditions diversions could occur only during the period January through July because the hydraulic head at this location is inadequate during the remainder of the year. Diversions are required March to November to attain the desired salinity regime. Further in investigations were made to determine whether a storage impoundment could be created in the marshes between the hurricane back protection levee and the hurricane protection levee adjacent to the MR-GO and GIWW. Such an impoundment was considered impractical because the

TABLE B-2-1

RIVERBEND SITE

Supplemental Flows Required to Achieve
Desired Salinity Conditions at Location #2

Month	Supplemental Flow (cfs)	Desired Salinity Location #2 (ppt)	With-Project Salinity Location #2 (ppt)
Jan	0	15-17	14.2
Feb	0	13-15	12.2
Mar	16,200	11-13	9.6
Apr	45,000	7-9	8.0
May	25,000	6-8	8.0
Jun	21,900	12-14	12.5
Jul	4,800	12.5-13.5	13.0
Aug	3,900	15-17	16.0
Sep	3,000	16-18	17.0
Oct	8,300	16-18	17.0
Nov	4,800	15-17	16.0
Dec	0	15.5-16.5	16.0

hurricane protection levees would have to be raised and pumping stations and floodgates that provide drainage to the developed areas in St. Bernard Parish would have to be modified. About 24,000 acres of marsh would be inundated. A control structure and channel to divert 100 percent of the supplemental flow January thru July would cost about $137 million.

B.2.9. Officials from St. Bernard Parish have indicated that they will oppose a freshwater diversion project in their parish. They do support the concept of freshwater diversion and realize the need for additional freshwater in St. Bernard Parish. They have constructed a 250 cfs siphon at Violet, LA to provide supplemental water to adjacent wetlands. The parish has been issued permits by the Corps of Engineers and state to install flap gate culverts, upgrade spoil dikes, and construct new dikes in the marshes between the back hurricane protection levee and the hurricane protection levee adjacent to the MR-GO. Some of the improvements have been put in place. These improvements are envisioned to reduce saltwater instrusion in the area by conserving rain runoff and by water diverted through the Violet siphon. The parish does support the IHNC and Bonnet Carre' freshwater diversion site. The main reasons for opposition to the Riverbend site are listed below.

- The Violet siphon would not be needed if the Riverbend diversion is constructed. The public investment in the siphon would be lost.

- The diversion channel would bisect a large portion of St. Bernard Parish.

- The increased flow as a result of the diverted freshwater through the Bayou Dupre structure outlet would cause additional navigation problems to fishermen in the area.

- The water would be diverted too close to the oyster beds in Lake Borgne. The beds would be overfreshened and subjected to fecal coliform contamination.

- The increase in water levels in the marshes as a result of the diverted water would aggravate drainage problems in the area

bounded by Violet Canal, back levee, diversion channel, and Mississippi River levee.

o Several scenic streams would be impacted by the proposed diversion. They are Bayou Dupre, Bashman Bayou, Terre Beau Bayou, Pirogue Bayou and Lake Borgne Canal.

o Diversion channel required to convey a peak flow would be of sufficient size to support deep-draft navigation. The diversion structure could be modified to include a navigation lock. Deep-draft navigation would then be possible between the Mississippi River and MR-GO. This type of channel may encourage industrial development in the parish which is undesirable at this time.

o The plan to install culverts and dikes in the marsh would not be necessary. The public investment in the construction of portions of the plan would be lost.

Plan A was eliminated because it could not achieve the desired salinity regime and the Plan does not meet any of the performance criteria.

PLANS B AND C (RIVERBEND AND BONNET CARRE' SITES)

B.2.6. Plans B and C use the Riverbend site in combination with the Bonnet Carre' site. To achieve the same salinity conditions, the Riverbend site would require 1.50 times the water required at the Bonnet Carre' site. The additional flow is required at the Riverbend site because a significant portion of the diverted flow would be lost to the Gulf of Mexico via the MR-GO at ebb tide. The water loss at ebb tide would only affect the salinity in the MR-GO and adjacent marshes. Plan B is based on diverting 75 percent of the required flow from the Bonnet Carre' site and 25 percent from the Riverbend site. The total

peak flow required is about 33,800 cfs. Of this total, 22,500 cfs would be the peak design flow at the Bonnet Carre' site and 11,300 cfs would be the peak design flow at the Riverbend site. Placing the structure in the Bonnet Carre' Spillway was considered. The engineering analysis indicated that modifying the spillway structure for freshwater diversion would be too expensive. Additional information on modifying the structure can be found in the discussion of Plan F. Both structures could be operated during the period March through July. However, only the Bonnet Carre' site structure would be capable of diversions during the period August through November. The estimated construction first cost of the Bonnet Carre' site for plan for plan B is $41 million. The estimated construction first cost for the Riverbend site is estimated at [illegible] million. The total estimated cost is $85 million.

B.2.7. Plan C is based on a distribution that half of the peak flows by using the Bonnet Carre' site were to be furnished at that site and half of peak flows required by using the *Riverbend* site were furnished at that site. On this basis, the peak design flow at Riverbend would be 22,500 cfs and at Bonnet Carre' site, 15,000 cfs. The construction first cost for a 22,500 cfs structure and channel is estimated at $79 million for the Riverbend site. The estimated cost of diverting 15,000 cfs at the Bonnet Carre' site is $30 million. The total cost of this plan would be about $109 million.

B.2.8. Plans B and C were eliminated because the plans would not be economically feasible and the plans would not meet the performance criteria of efficiency and acceptability. Plans B and C do not meet the criterion of efficiency beause they would require that more supplemental fresh water be diverted to achieve the desired salinity regime. Fifty percent of the water diverted at the Riverbend site would be lost in the MR-GO at ebb tide. These plans contain two diversion sites that would require more land acquisition. More overall adverse impacts to the

[illegible] although the impacts would be less at the [illegible] site since only a portion of the flow is being diverted. At the Riverbend site, marsh would be converted to conveyance channel and [illegible] oyster beds in Lake Borgne may be temporarily or permanently closed because of high fecal coliform counts. The Riverbend diversion site is located too close to oyster beds in Lake Borgne to allow fecal coliform organisms in the Mississippi River to die-off. River sediments that would settle out in Lake Borgne would cover oyster beds and adversely affect oyster growth. Plans B and C do not meet the criterion of acceptability. As previously indicated, officials of St. Bernard Parish have expressed opposition to a diversion site in their parish. Consequently, Plans B and C were eliminated from consideration.

PLAN D (INNER HARBOR NAVIGATION CANAL SITE)

B.2.9. Another study, "Mississippi River-Gulf Outlet, New Lock and Connecting Channels," is being conducted to determine the feasibility of rehabilitating or replacing the existing Industrial Canal lock (plate B-7). Numerous potential shiplock locations as well as the existing location of the lock are being investigated to determine the most suitable. A location selection study completed in March 1975 concluded that only two sites merit detailed study, one at or near the existing lock and one designated as the lower Violet site. Detailed studies are underway and a study completion date has not been determined.

B.2.10. Since the final shiplock location has not been determined, three schemes were developed to investigate freshwater diversion at the IHNC site. In the first scheme, 18 combinations of lock types and sizes were considered using various operational modes. The 18 combinations are described in table C-1-30, Appendix C, Engineering Investigations. The overriding concern in all three schemes was to accommodate fresh

water diversion without adversely affecting navigation through the lock. As a result, the volume of the diverted water was limited by this constraint. Analysis of the 18 lock and operational mode combinations determined that the year-round permissable volume of water that could be diverted through the locks would be less than the supplemental flows needed. The largest volume of water that could be diverted was in combination No. 13. In this combination, the existing 31.5' x 75' x 640' IHNC lock would be modified to a 50' x 150' x 1200' lock with vertically pinned or rising sector gates at the existing lock location. Only a maximum of 90 percent of the required supplemental flow could be diverted in September and a low of 14 percent in April. Therefore, the first diversion scheme was eliminated from consideration.

B.2.11. The second diversion scheme assumes that the existing lock culvert system would be used to divert fresh water without modification. Hydraulic analysis was performed to determine the maximum monthly supplemental flow that could be diverted through the culvert system. The computed supplemental flows are shown in Table B-2-2.

TABLE B-2-2

IHNC SITE

Supplemental Flows Diverted Through the Existing Lock Culvert System

Month	Supplemental Flow (cfs)	Month	Supplemental Flow (cfs)
Jan	1,890	Jul	1,464
Feb	2,369	Aug	1,010
Mar	2,892	Sep	-
Apr	3,047	Oct	553
May	2,821	Nov	903
Jun	1,916	Dec	1,237

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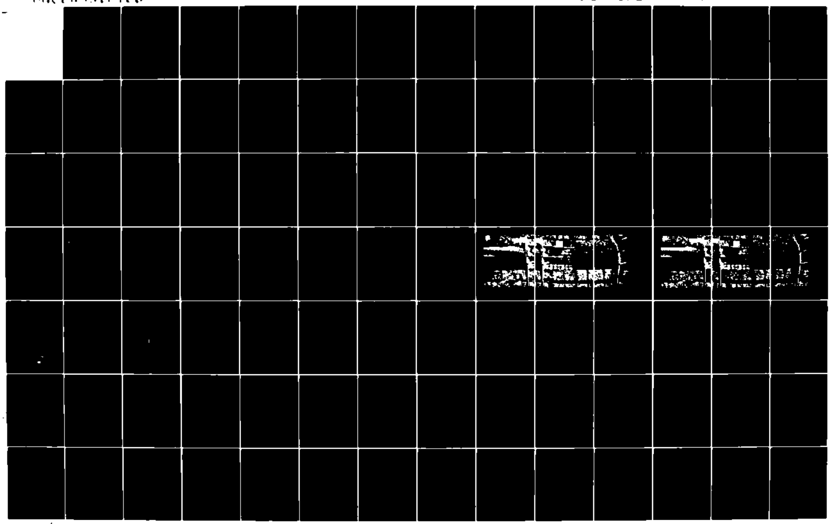

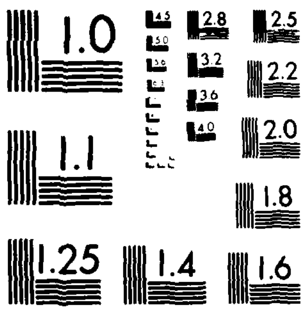

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B.2.12. As indicated in the table, supplemental water is available through the existing lock system in all months except September, but the peak discharge is only 3,047 cfs. Therefore, the supplemental water available to be diverted is of such small magnitude that it would not have a significant effect on establishing the desired salinity regime at Location #2. Thus, the second diversion scheme was eliminated from consideration.

B.2.13. In the third diversion scheme, the possibility of constructing a freshwater diversion channel adjacent to the existing lock within the existing rights-of-way was considered. The largest structure that could be constructed within the existing rights-of-way would consist of three 10-foot diameter concrete culverts approximately 400 feet long (plate B-8). The supplemental flows that could be diverted through the culvert system based on average monthly head differentials are shown in table B-2-3.

TABLE B-2-3

IHNC SITE

Supplemental Flows Diverted Through Culvert System
Adjacent to the Existing Lock

Month	Supplemental Flow	Month	Supplemental Flow
Jan	6,000	Jul	5,700
Feb	7,600	Aug	4,600
Mar	8,700	Sep	4,300
Apr	9,500	Oct	4,200
May	9,100	Nov	4,200
Jun	7,100	Dec	4,500

B.2.14. The flows that could be diverted through a culvert system can be accomplished only with the existing lock or by modifying the existing lock with a longer chamber to accommodate lockage of more vessels per operational mode. However, the supplemental flows capable of being diverted shown in table B-2-3 are insufficient to establish the desired salinity regime. The estimated cost of the diversion structure is $31 million. Further study of the IHNC site with the diversion structure adjacent to the existing lock was curtailed because the supplemental flow required to establish the desired salinity regime could not be achieved.

PLAN E (IHNC AND BONNET CARRE' SITES)

B.2.15. To achieve desirable salinity conditions with plan E, the IHNC plan that produced the maximum freshwater diversions was used in combination with flows from the Bonnet Carre' site. At the IHNC site the culvert system adjacent to the existing lock produced the maximum peak flow of 9,500 cfs. Therefore, the IHNC peak flow would have to be supplemented by a 25,000 cfs structure at the Bonnet Carre' site. The freshwater diversion structure at the Bonnet Carre' site would be placed just upriver of the spillway structure. The estimated cost of a 25,000 cfs structure at the Bonnet Carre' site is $50 million. The total estimated cost of this plan is $81 million. Plan E does not meet the efficiency and acceptability criteria. The design capacity of the diversion structure at the Bonnet Carre' site is only 17 percent less than the capacity ot a diversion structure required to divert 100 percent of the flow at the Bonnet Carre' site. However, the cost of Plan E is 40 percent greater than diverting 100 percent of the flow at the Bonnet Carre' site. In addition, half of the Mississippi River flow diverted at the IHNC would be lost in the MR-GO and GIWW on ebb tide and would only benefit the marshes immediately adjacent to these water bodies. Oyster beds in Lake Borgne may be temporarily or permanently

closed because of high fecal coliform counts. The IHNC site is located too close to the oyster beds in Lake Borgne to allow fecal coliform organisms in the Mississippi River water to die-off. Several industries adjacent to the IHNC discharge wastewaters into the IHNC along with waste from vessels that utilize the waterway. The City of New Orleans discharges stormwater runoff into the IHNC. The water quality of the IHNC is adversely affected by these wastewater discharges and has been classified as water quality limited. Coliform counts exceed water quality criteria frequently. A diversion site adjacent to the existing IHNC would be opposed by the City of New Orleans and the shipping industry. The City of New Orleans would not receive any direct benefits from the project and the shipping industry would be concerned by adverse impacts of navigation in terms of greater velocity through the IHNC than normal when water is being diverted. Therefore, Plan E was eliminated from consideration.

PLAN F (BONNET CARRE' SITE)

B.2.16. Plan F consists of a site at the Bonnet Carre' Spillway. One option considered for Plans B, C, E, and F was modifying part of the existing spillway structure for freshwater diversion. The existing structure, with a sill elevation of 16.1 feet NGVD, was designed to operate only during high water periods on the Mississippi River. However, freshwater diversions are required only during periods of average to low flow on the river. The sill elevation necessary to provide adequate freshwater diversions to achieve the objectives is -21.0 feet NGVD. Overall, modifying the existing spillway structure to allow diversion during average to low flow on the river would be expensive and would require part of the spillway structure to be inoperative for at least 2 years.

B.2.17. Plan F meets all the performance criteria and the desired salinity regime can be achieved. Plan F provides and accounts for all necessary investments and actions to ensure that the contributions to the planning objectives are realized. However, it is assumed that other Federal, state and local agencies would continue to implement their program to regulate alteration of wetlands, fill open water areas, and manage the fish and wildlife resources of the study area.

B.2.18. The Bonnet Carre' Plan is the most effective and efficient plan in providing the required supplemental flow and in maximizing benefits. Plans A and D could not divert enough water to provide the required supplemental flows. Plans B, C, and E would require 13, 25, and 75 percent more water, respectively, to attain the desired optimum salinity regime. The plan would be more expensive because the total length channels would be longer, more habiat would be altered, and more relocations would be required.

B.2.19. Plan F has one of the shortest conveyance channels. The 6.6 mile conveyance channel would use 2.0 miles of the existing borrow channel. Therefore, ony 4.6 miles of channel excavation is required. Most of the excavation is through areas classified on the fish and wildlife habitat maps or upland developed areas which have low values for fish and wildlife. Plan F is accepted by Federal and Louisiana and Mississippi state agencies concerned with fish and wildlife resources. The plan has a low probability of uncovering cultural resources.

B.2.20. Adverse water quality impacts associated with Plan F would be limited to the southwestern portion of the lake in the vicinity of the outfall canal. These impacts include increased turbidity, nutrients, coliform counts and slightly lower temperatures. Beneficial effects on western Lake Pontchartain from the diversion include higher dissolved oxygen levels and lower coliform concentrations along the southern shore

in Jefferson and Orleans Parishes, particularly in the vicinity of stormwater outfall canals. During periods of diversion, the low salinity waters in Lake Pontchartrain may displace brown shrimp, spotted seatrout, red drum, and other estuarine species to eastern Lake Pontchartrain and Lake Borgne. During years of lesser diversion or no diversion at all, there will be little or no adverse impacts on these species. They will be benefitted due to the increased nutrients in the system. Even in years of maximum design diversion, salinities would return to near normal conditions during the fall and winter months.

B.2.21. Engineering analysis of modifying part of the existing spillway structure for freshwater diversion or placing the diversion structure adjacent to the existing structure revealed that it would cost $5,200,000 more to modify the spillway structure for freshwater diversion. The increased cost is because the existing gates would have to be removed and then reconstructed for freshwater diversion and cofferdams would be needed to protect the work site from Mississippi River overflow. The structure above the culverts would be reinforced concrete instead of embankment and an additional bridge over the conveyance channel would be required to provide continued access to the road on the landside of the structure. Therefore, it was determined that the freshwater diversion structure should be located just upriver of the spillway structure.

B.2.22. Another option investigated was location of a freshwater diversion structure adjacent to the existing structure. Site investigations determined that the diversion structure should be placed just upriver of the existing structure. Land acquisition would be small and relocations would be held to a minimum.

B.2.23. Supplemental flows computed at the Bonnet Carre' site to achieve the desired salinity regime during 50-percent drought conditions

are given in table B-2-4. Sufficient hydraulic head is available to design a freshwater diversion structure that could pass the required supplemental flow.

B.2.24. Supplemental water could be diverted nine months in the year (March-November). The maximum design flow requirements would be diverted on an average of every other year. The analysis of the site indicated that no constraints exist that could not be reasonably overcome in the engineering design of the diversion structure, channel, and associated works. The estimated first cost of construction is about $57.8 million. Plan F was retained.

RATIONALE FOR NATIONAL ECONOMIC DEVELOPMENT PLAN

B.2.25. Plan F is the least costly and yields the maximum excess benefits over costs of the alternative plans. Modifying Plan F to divert less or more than 30,000 cfs would move the position of the desired salinity regime inland or seaward of Location #2. The supplemental flow requirements to achieve the desired salinity regime at five locations were analyzed:

- o Location #1
- o between Locations #1 and #2
- o Location #2
- o between Locations #2 and #3
- o Location #3

No supplemental flow is required to achieve Location #1. A structure capable of diverting 20,000 cfs would be required to achieve the desired salinity regime between Locations #1 and #2. If the desired salinity regime were established between Locations #1 and #2, a large majority of

TABLE B-2-4

REQUIRED SUPPLEMENTAL FLOWS AT THE BONNET CARRE' SITE WITH DESIRED WITH-PROJECT SALINITY

Month	Supplemental Flow	Desired Salinity @ Location #2	With-Project Salinity @ Location #2
Jan	-	15-17	14.2
Feb	-	13-15	12.2
Mar	10,800	11-13	9.6
Apr	30,000	7-9	8.0
May	16,700	6-8	8.0
Jun	14,600	12-14	12.5
Jul	3,200	12.5-13.5	13.0
Aug	2,600	15-17	16.0
Sep	2,000	16-18	17.0
Oct	5,500	16-18	17.0
Nov	3,200	15-17	16.0
Dec	-	15.5-16.5	16.0

the public oyster reefs and privately leased water bottoms would be seaward of the desired salinity regime created by the diversion. Increased oyster production would be only 58 percent of the production at Location #2 and just 20 percent greater than existing oyster production. The cost of a diversion structure capable of diverting 20,000 cfs to achieve the desired salinity regime between Locations #1 and #2 is an estimated $46 million. Benefits attributable to the increased oyster production in the study area are estimated at $2,588,000. The average annual cost of this diversion project is $4,300,000. The benefit-cost ratio is 0.6 to 1.

B.2.26. If the desired salinity regime was established at Location #2, these optimal conditions would be directly over the area that was

historically productive in the past. At Location #2, 83 percent of 10,000 of the 12,000 acres of known oyster reefs in the public grounds are located in the zone created by the desired salinity regime zone. This optimal salinity zone at Location #2 would encompass 33,000 acres of the 51,000 acres of leased water bottoms or about 65 percent of the leased bottoms. In Mississippi, 7,500 of the 10,800 acres of oyster reefs or about 69 percent are located within the optimal zone. With the desired salinity regime at Location #2, oyster production would increase by 105 percent. Reestablishing oyster production in the St. Bernard marshes would move much of the production farther from possible pollution of the New Orleans metropolitan area. Oyster beds in Lake Borgne, the location of most of the Louisiana oyster production, have been closed on several occasions because of high coliform counts. At Location #2, most of the oyster production would be in the St. Bernard marshes where some of the pollutants could be assimilated by the marshes before reaching the oyster beds. The coliform would have the opportunity to die off before reaching the oyster beds.

B.2.27. During Bonnet Carre' Spillway openings, oyster mortality rates in Lake Borgne have been as high as 95% because of overfreshening and lower temperatures. If production is reestablished at Location #2, mortality rates during spillway openings would be reduced because the fresh water would be more widely dispersed throughout the marshes and the fresh water would be diluted with higher salinity waters from Chandeleur Sound.

B.2.28. Establishing the desired salinity regime between Locations #2 and 3 would significantly reduce project benefit areas. None of the reefs in Mississippi would be in the optimal salinity zones. Most of Lake Borgne and adjacent marshes would be eliminated from oyster production. Overall oyster production would probably be lower than existing conditions. Displacement of estuarine species less tolerant of

low salinity waters would be greater and the impacts on brown shrimp, speckled trout, and red drum would be greater. A structure capable of diverting [illegible] cfs would be required to achieve the desired salinity conditions between Locations #2 and #3.

B.2.29. Establishing the desired salinity regime at Location #3 would require a diversion of approximately 180,000 cfs. If the desired regime were created, most of the public oyster reefs and privately leased water bottoms would be inland of this optimal zone. The large quantity of fresh water would adversely overfreshen most of Lake Pontchartrain and Lake Borgne. Oyster productivity would be reduced below existing condition production. The estimated first cost of a structure capable of diverting 180,000 cfs is in excess of $200 million. Such a project would lack adequate benefits to make it economically feasible.

B.2.30. Plan F, with a structure capable of diverting 30,000 cfs, has the greatest benefit-to-cost ratio and contributes the maximum intangible benefits. The plan would have fewer adverse environmental impacts, thus, Plan F is designated as the National Economic Development (NED) plan.

RATIONALE FOR THE RECOMMENDED PLAN

B.2.31. The Bonnet Carre' plan is the most desirable plan from a national economic development and environmental quality perspective. The plan is the least costly and would provide the most average annual excess benefits over costs. The plan minimizes adverse impacts and maximizes the tangible and intangible benefits to environmental quality. Plan F is generally accepted by Federal and Louisiana and Mississippi agencies concerned with fish and wildlife resources. The States of Louisiana and Mississippi have furnished letters that indicate their intention to provide the necessary funds and local cooperation at

the appropriate time. Numerous meetings have been held with state, parish, and local agencies and interested groups. Three public meetings were held in December 1983. The plan is generally supported by people in the study area. St. Charles and St. Bernard Parishes passed resolutions supporting the recommended plan dated December 19, 1983, and [illegible], 1983, respectively. Resolutions passed supporting the project are contained in Appendix L, Public Views and Responses.

8.[illegible].32. The St. Charles Parish resolution requested that the Corps of Engineers purchase the entire community of Montz bounded by the Bonnet Carre' Spillway, River Road, the Louisiana Power and Light Company Little Gypsy power plant, and the Illinois Central Gulf Railroad (Plate 8-9). The plan as originally designed would require that 26 homes and 6 trailers be relocated. The modification of the plan as requested by St. Charles Parish would require that 52 single family dwellings, 16 trailers, and 1 church be relocated. The acreages that must be acquired would increase from 61.2 to 77.2. The community of Montz is a predominantly low-income community and most of the residents are closely related. There is a strong sense of cohesiveness in Montz. Several residents of the community have indicated that three and four generations of their family live in Montz and they have no desire to live apart. At the Corps public meeting in Destrehan, Louisiana, on December 6, 1983, the councilman representing the community presented a petition signed by 24 residents requesting that the community be relocated as a unit. Relocating the community as a unit would increase the cost of the project by $1.6 million. The New Orleans District of the Corps of Engineers concurs with the request and the recommended plan has been revised accordingly.

9. [illegible] RECOMMENDED PLAN

9.3. [illegible]

9.3.1. The [illegible] river diversion plan at Bonnet Carre' is shown on Plates B-1 and B-11. Development at the Bonnet Carre' site would consist of a salinity control structure, inflow and outflow channels, sedimentation trap, access bridge, and recreational facilities. In addition, recreational facilities are included in the plan at Frenier Beach, the Rigolets and Point Aux Herbes in Louisiana and on the Wolf River and Cedar Point in Mississippi.

9.3.2. The salinity control structure would be located about 600 feet upriver of the Bonnet Carre' Spillway and approximately 550 feet landward of the existing Mississippi River levee. The structure is four 20- by 20-foot gated box culverts with an invert elevation of -21.0 feet NGVD. The Mississippi River levee would be set back to tie into the diversion structure. The inflow channel between the Mississippi River and the structure would be about 950 feet long with a bottom width of 300 feet, 1V on 3H side slopes, and a water depth of 25 feet at the 50 percent exceedance Mississippi River stage. The outflow channel between the structure and Lake Pontchartrain via the floodway would be alined in a northeasterly direction from the diversion structure for a distance of 0.6 miles. From the control structure to the floodway, the channel length would be about 0.2 mile. The outflow channel would then be alined parallel to the upper Bonnet Carre' Spillway guide levee for a distance of 1.0 mile. To avoid the Airline highway (US 61) earthen embankment, the channel would be alined in a northeasterly direction for 1.0 mile above Airline highway. The outflow channel would run northwesterly for a distance of 1.1 miles where it would enter an existing borrow channel. The borrow channel has sufficient capacity to convey the design flow. Depths vary from 25-45 feet, widths range from 300 to

400 feet, and it would be used for 2.0 miles. After leaving the borrow channel, the outflow channel would be alined in a more northeasterly direction to avoid the upper guide levee since the channel would widen as it enters Lake Pontchartrain. The channel distance would be 0.7 mile, which extends into Lake Pontchartrain. The total outflow channel length would be 6.4 miles. The outflow channel would have a bottom width of 400 feet, 1V on 3H sideslopes, and a water depth of 25 feet. The diversion channel would be designed to contain all diverted flows within banks. The invert elevation of the outflow channel would be -21 feet NGVD at the control structure.

B.3.3. The first 3.8 miles of the channel would be a new channel cut from the diversion structure to the borrow channel above Airline highway. A new channel cut would be required from the borrow channel to Lake Pontchartrain. To avoid relocating Interstate 10, the channel bottom width and lengths would be modified. The channel bottom width would be increased to 590 feet and then to 760 feet over a channel length of 1,025 and 336 feet, respectively. The depth of the channel would be decreased to 10 feet and then to 2 feet over the same lengths.

B.3.4. The distance from the channel centerline to the centerline of the upper guide levee would vary from a minimum distance of 360 feet near the diversion structure to a maximum distance of over 2,350 feet at Airline highway. The distance from the centerline of the upper guide levee to the centerline of the existing borrow channel is 1,050 feet. That portion of the channel parallel to the upper guide levee between the spillway structure and Airline highway is approximately 1,110 feet from the centerline of the levee except at the sediment trap. At the sediment trap, the distance would be approximately 875 feet.

B.3.5. The channel would be excavated by bucket dragline in the floodway and bucket dragline on barges in open water areas in Lake

for Lake Borgne and surrounding marshes to return to near normal conditions. The short detention time is a result of the large volume of open water and the interchange of saltwater with the gulf. Analyses performed by Gagliano under contract to the Corps of Engineers indicate that even during a wet year, 1961, salinities in the Lake Pontchartrain-Borgne Basin were consistently higher than 15 ppt in the vicinity of the proposed Ford line. Gagliano indicated that some water would have to be diverted even during wet years. He suggested that the position of the Ford line may be too far seaward. Analysis of monthly flows that can be diverted through the structures as designed indicates that none of the options considered would maintain desirable salinity conditions year-round. Under option 1, desirable salinity conditions could be maintained January through May and in November. Options 2 & 3 could maintain desirable salinities January through May and in November. Option 4 could maintain desirable conditions January through May. If Options 1 and 4 were used together, supplemental flow requirements could be met in all months except August and September.

The first cost of option 1 added to option 4 is $167 million ($13,000,000 on an average annual basis). However, preliminary benefit calculations show that average annual benefits for the project would be about $3,800,000. This includes about $1,000,000 in recreation benefits for providing additional access and recreation facilities (boat ramps). Over 90 percent of the remaining $2,800,000 in benefits is attributable to increased oyster production. These benefits would support a first cost of approximately $50,000,000. The least cost alternative is option 1 at $68.2 million.

Ms. Suzanne Hawes presented the biological implications of study findings to date. She said that the possible diversion options investigated would cause several major biological problems. Current data indicates that year-round diversion of freshwater would be necessary to attain the Ford line due to the short detention time in the Pontchartrain-Borgne Basin. The river averages 6-8 C cooler than the receiving waters from January through April and differences of 10-12°C are common. Twenty-degree differences have been recorded. Temperature differences between the river water and the lake could affect species such as brown shrimp. The short retention time in this basin means that the cold water would reach the estuarine areas before warming significantly. As the year progresses, temperature differences between the river and the lake become less and less and are negligible by late summer and early fall. Brown shrimp production drops when water temperature is below 20°C and salinities are below 10 ppt. This combination could occur far more frequently than it does now if we attempt to attain the Ford line. It is possible that other species could be adversely affected by the cool river water. The short retention time and year-round structure operation could necessitate prolonged closing of oyster leases in Lake Borgne as a result of high fecal coliform counts.

If the Ford line is attained, another problem would revolve around the position of the 5 ppt isohaline. The large amount of freshwater required to maintain the Ford line would push the 5 ppt isohaline to the eastern shore of Lake Borgne. Oyster reproductive capacity is reduced at salinities below 6 ppt and death occurs after prolonged exposure to salinities below 5 ppt. Thus, attaining the Ford line would have an adverse impact on the Lake Borgne oyster fishery. Moving the 5 ppt isohaline to the east would change the nature of the sport and commercial fishery in Lake Pontchartrain and

Among the important products produced by the group was identification of desirable salinity conditions for fish and wildlife in Coastal Louisiana and supplemental water requirements to achieve the salinity conditions. The desirable condition for fisheries productivity was defined by the position of the 15 ppt mean salinity isohaline constructed across the coastal zone from April through September. The position, known as the Ford line, is located along the seaward edges of the marshes surrounding Lake Borgne just west of Chandeleur Sound. The desirable condition for wildlife productivity was defined by the position of the 15 ppt isohaline constructed across the coastal zone October through March. This position, the Palmisano line, is located just east of Lake Borgne. The supplemental flows required to maintain the desired salinity gradients were determined by Sherwood Gagliano et al. (1971) under contract to the New Orleans District. These flow requirements were used in the design of the structures and channels at the sites.

Mr. Hull said that the purpose of the Mississippi and Louisiana Estuarine Areas study was to determine the advisability of introducing freshwater into Lakes Maurepas, Pontchartrain, and Borgne and Mississippi Sound in the interest of improving the wildlife and fisheries resources of this area. A reconnaissance scope report was submitted in July 1981 and has been approved by the Mississippi River Commisson (MRC). In that report, 13 possible sites were identified for diverting supplemental flows of freshwater to alter salinity conditions in the estuaries. The optimum salinity conditions in the estuaries are those determined by the ad hoc group early in the overall Louisiana Coastal Area study. To obtain optimum salinity conditions during a 10 percent drought would require about 27,000 cfs from April through September and between 10,000 and 24,000 cfs the rest of the year.

The 13 possible freshwater diversion sites have been screened to 2 sites. One of the sites is located just north of the Bonnet Carre' Spillway (BCS) and is adjacent to the Bonnet Carre' structure. A channel cut through the spillway would be used to convey the diverted water to Lake Pontchartrain. The other site is located below New Orleans between the communities of Riverbend and Violet. Water would be diverted through the marshes and hurricane protection levees across the Mississippi River-Gulf Outlet through Lake Borgne Canal (LBC) to Lake Borgne. Several options were analyzed to determine the most economically feasible combination of supplemental flows at the two sites.

Option 1	100 percent flow at the site just north of Bonnet Carre Spillway (BCS)
Option 2	75 percent flow at BCS and 25 percent flow at Lake Borgne Canal (LBC)
Option 3	50 percent flow at BCS and 50 percent flow at LBC
Option 4	100 percent flow at LBC

In the Louisiana Coastal Area study, structures were designed to divert water from January through April to maintain the desired salinities from April through September. The Lake Pontchartrain-Borgne Basin would require year-round diversion of freshwater to maintain the desired salinities during a 10-percent drought condition. Based on past Bonnet Carre Spillway openings, it only takes several weeks to a month and a half after the spillway is closed

MISSISSIPPI AND LOUISIANA ESTUARINE AREAS STUDY

Ad Hoc Group Meeting

28 May 1982

The first meeting of the ad hoc group was held on 28 May 1982 at 10:00 a.m. in US Army Corps of Engineers Conference Room #1. Mr. John Weber, Chief, Environmental Analysis Branch, Planning Division, presided at the meeting. Attendees and the agency represented are listed below.

Name	Agency
John Weber	US Army Corps of Engineers
Sue Hawes	US Army Corps of Engineers
Burnell Thibodaux	US Army Corps of Engineers
Ralph Latapie	La. Dept. of WL&F, New Orleans
Mark Chatry	La. Dept. of WL&F, Grand Terre, LA
Fred Deegen	Miss. Bureau of Marine Resources, Long Beach, MS
Barney Barrett	La. WL&F, Baton Rouge
Chuck Killebrew	La. WL&F, Baton Rouge
David Chambers	Coastal Management/DNR
Ted B. Ford	La. Dept. of WL&F, Baton Rouge & N.O.
Donald Moore	National Marine Fisheries Svc., Galveston, TX
Johannes L. Van Beek	Coastal Management/DNR (consultant)
Jay Combe	US Army Corps of Engineers
Falcolm Hull	US Army Corps of Engineers
David Fruge'	US Fish and Wildlife Service
Margaret Balzer	St. Bernard Parish Planning
Marc Solomon	US Army Corps of Engineers

Mr. Weber stated that the purpose of reconvening the ad hoc group is to: 1) provide the group an up-to-date briefing on the Mississippi and Louisiana Estuarine Areas study, 2) present results of analysis performed to date and difficulties that have been identified relative to achieving study objectives, 3) obtain the group's views on whether study objectives should be modified, and 4) determine a procedure for modifying study objectives, if warranted. Mr. Weber asked Mr. Falcolm E. Hull, Project Manager, to brief the group on the study status. Mr. Hull reviewed the information in the packets prepared for the meeting (inclosure 1). He stated that the ad hoc group was established in 1969 by the Corps of Engineers to provide input to several Corps studies: Louisiana Coastal Area; Lower Mississippi Region Comprehensive, West Texas and Eastern New Mexico Import; and Atchafalaya Basin (Land and Water Resources) studies. The group provided the following:

- A comprehensive evaluation of fish and wildlife resources in coastal Louisiana.
- Documentation of the needs for preserving and enhancing the resources.
- Recommendations for meeting the needs.

- Section 601 of Title VI of the Civil Rights Act of 1964 (PL 88-352) that no person shall be excluded from participation in, denied the benefits of, or subjected to discrimination in connection with the project on the grounds of race, creed, or national origin; and

- The applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646.

Pontchartrain and in Mississippi:

- Acquire in its name and dedicate to public outdoor recreational use an adequate interest in all lands on which cost-shared recreational facilities and improvements for access, parking, potable water, sanitary facilities and related developments for health and safety are provided, with credit as specified below.

- Make an additional contribution sufficient to raise the non-Federal share to at least 50 percent of the total first cost of adding recreation to the project, where the appraised value of separable lands that are eligible for credit is less than that percentage. Such additional contribution may consist of the actual cost of carrying out an agreed-upon portion of the development within a specified time frame, a cash contribution during the construction period, or a combination of the above.

- Operate, maintain, and replace without cost to the Federal government, for the economic life of the project, the recreation areas and all facilities installed pursuant to the agreement.

- Hold and save the United States free from damages due to the construction works except where such damages are due to the fault or negligence of the United States or its contractors.

In addition, the non-Federal entity must agree to comply with the following:

- Section 221, Public Law 91-611, approved 31 December 1970, as amended;

amended,

o Section 601 of Title VI of the Civil Rights Act of 1964 (PL 88-352) that no person shall be excluded from participation in, denied the benefits of, or subjected to discrimination in connection with the project on the grounds of race, creed, or national origin; and

o the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646.

B.3.16. The Federal government will credit the costs and expenses incurred in the acquisition of the required real estate interests toward the non-Federal share of the project construction costs.

B.3.17. The Federal government will require the right to enter at reasonable times and in a reasonable manner upon land which the sponsor owns or controls for access to the project.

B.3.18. As part of the operation and maintenance of the project, the Corps of Engineers and the states of Louisiana and Mississippi will establish a two-state interagency advisory group to participate in decisions governing structure operation. This group should include people from local, state, and Federal sectors knowledgeable in the multiple needs of fish and wildlife resources, navigation, water supply, and flood control. In addition, the group should include people to represent sport and commercial fish and wildlife interests. The states must also maintain a network for collecting hydrological, water quality, and biological data essential for determining the best use of diverted water.

B.3.19. The states must agree to comply with the following requirements before construction of recreational facilities along the shore of Lake

IMPLEMENTATION RESPONSIBILITIES

B.3.13. The States of Louisiana and Mississippi must agree to comply with requirements for construction of the freshwater diversion control structure, channels, and associated works.

B.3.14. They must agree to comply with requirements for construction of recreational facilities planned within the floodway and at Frenier Beach, the Rigolets, and Point Aux Herbes in Louisiana. Two locations in Mississippi are also planned for the development of recreational facilities.

B.3.15. Before features of the Bonnet Carre' plan can be constructed, the states must agree to comply with the following requirements:

- o Provide, without cost to the United States, all lands, easements, and rights-of-way necessary for construction and operation of the works;
- o Hold and save the United States free from damages due to the construction works except where such damages are due to the fault or negligence of the United States or its contractors;
- o Operate and maintain the works after completion;
- o Contribute 25 percent of the project construction costs;
- o Assure adequate public access to the project area.

In addition, the non-Federal entities must agree to comply with the following:

- o Section 221, Public Law 91-611, approved 31 December 1970, as

COST SHARING

B.3.12. Cost sharing policies for enhancement of fish and wildlife, the primary function of the plan, provides for first cost to be shared on a 75 percent Federal and 25 percent non-Federal basis. Cost sharing policies for recreation facilities provides for first costs to be shared on a 50 percent Federal and 50 percent non-Federal basis. Non-Federal interests must also assume all costs for operation, maintenance, and replacement. Under these policies, the current estimated first cost of $57,814,000 is apportioned $43,175,000 Federal and $14,639,000 non-Federal. All of the estimated average annual operation, maintenance, and replacement costs of $822,000 would be borne by non-Federal interests. On an annual basis, the annual cost of $5,963,000 is apportioned $4,456,000 Federal and $1,507,000 non-Federal. Benefits attributable to the recommended plan would accrue to the States of Louisiana and Mississippi. About 80 percent of the project benefits would occur in Louisiana and about 20 percent in Mississippi; therefore, the non-Federal share of the cost was distributed on that basis. Louisiana's share of the project would be $11,700,000 and Mississippi's share would be $2,939,000. The states furnished letters dated January 26, 1984, and February 29, 1984, indicating their intention to provide the necessary funding and the local cooperation at the appropriate time. The distribution of cost between Federal and non-Federal sponsors is shown below:

Feature	Federal	Non-Federal		Total
		Louisiana	Mississippi	
Structure, channel, and associated works	$42,803,700	$11,450,400	$2,817,200	$57,071,300
Recreation	$371,300	249,600	121,800	742,700
Total	$43,175,000	$11,700,000	$2,939,000	$57,814,000

TABLE B-3-2 (Continued)

Summary Presentation And Assessment of Bonnet Carre' Plan

	Existing Conditions	Future Conditions (No-Action) 2040	Plan 1
c. Net Regional Economic Development			Slightly Positive
d. Net Social Effects			Slightly Positive
3. Plan Response to Associated Evaluation Criteria			
a. Acceptability			Most Federal, state, and local interest support the project
b. Efficiency			Most efficient plan
c. Geographic Scope			Maintain desired conditions over largest area
e. Effectiveness			No other measures are required to realize benefits except for those currently being implemented by other Federal and local agencies
f. Certainty			Very likely that contributions to planning objectives would be realized.
g. NED B/C Ratio			1.20
h. Reversibility			Most reversible plan
i. Stability			Stable salinity regime would be established in study area. Variations in commercial fish and wildlife harvests would be reduced. Average annual commercial and sport harvest would be higher.
4. Rankings of Plans			
a. NED Objectives			1
b. EQ			1
c. Regional Economic Development			1
d. Social Well-being			1
IV. IMPLEMENTATION RESPONSIBILITY			
1. First Cost			
a. Federal			$ 43,[illegible],000
b. Non-Federal			$ 14,619,[illegible]
c. Total			$ [illegible]
2. Annual Cost			
a. Federal			$ [illegible]
b. Non-Federal			$ [illegible]
c. Total			$ [illegible]

1/ EPA and state marine water aquatic life criteria

Index of Footnotes:

Timing
1. Impact is expected to occur prior to or during implementation of the plan. 2. Impact is expected within 15 years following plan implementation. 3. Impact is expected in a longer time frame (15 or more years following implementation)

Uncertainty
4. The uncertainty associated with the impact is 50% or more. 5. The uncertainty is between 10% and 50%. 6. The uncertainty is less than 10%.

Exclusivity
7. Overlapping entry, fully monetized in NED account. 8. Overlapping entry, not fully monetized in NED account.

Actuality
9. Impact will occur with implementation. 10. Impact will occur only when specific additional actions are carried out during implementation. 11. Impact will not occur because necessary additional actions are lacking.

Section 122
*. Items specifically required in Section 122 and ER 1105-2-240.

TABLE B-3-2 (continued)

Summary Presentation And Assessment of Bonnet Carre' Plan

	Existing Conditions	Future Conditions (No-Action) 2040	Plan 1
3. Regional Economic Development			
a. Regional Income and Employment		Continued decline in employment and and income in fish and wildlife and related industries	Minor increase during construction, operation and maintenance. Long term increase in fish and wildlife and related industries (1,2,3,5,9)
b. Regional Growth and Business Activity		Continous decline in activities related to fish and wildlife	Revitalize the declining fish and wildlife related industries (2,3,5,9)
c. Tax Revenue*		Taxes derived from fish and wildlife activities would decline	Reduce loss of taxes derived from fish and wildlife (2,3,5,9)
d. Property Value*		Continued decline	Slight increase (2,3,5,9)
4. Other Social Effect			
a. Urban and Community Impacts			The community adjacent to the freshwater control structure would be adversely impacted due to the required relocation) (1,5,9)
b. Life, Health, and Safety			Improve quality of life for persons associated with the fish and wildlife industries No effect on health and safety (2,3,5,9)
c. Displacement of People			52 residences and 16 trailers displaced (1,5,9)
d. Long-term Productivity		Decline in fish and wildlife productivity	Increase fish and wildlife productivity (1,2,3,5,9)
e. Leisure	Leisure activities in the study area are primarily water based or water related such as hunting and fishing	Limited by access to fish and wildlife resources	Provides more opportunities for leisure by additional access to fish and wildlife resources proposed at recreational developments (2,3,5,9)
f. Aesthetics*			Temporary adverse visual impacts during construction. (1,5,9)
g. Community Cohesion	Unique cultural heritage and lifestyles dependent on fishing and trapping	Preservations of lifestyles and community cohesion difficult	Help maintain traditional lifestyle but community cohesion would be disrupted in vicinity of freshwater control structure due to relocations (1,2,3,5,9)
h. Community Growth*	Dependent on fish and wildlife industries	Population and opportunities would decline	Increase opportunities. Growth of community adjacent to structure [illegible] affected (1,2,3,5,9)
i. Transportation			Minor disruption of vehicular traffic during construction (1,5,9)
j. Noise			Minor increase of noise levels during construction (1,5,9)
k. Quality of Life			Increase opportunities and maintaining the quality of life, may improve for some persons relocated due to opportunities to get improved houses (1,2,3,5,9)
II. PLAN EVALUATION			
1. Contribution to Planning Objectives			
a. Increase commercial fish and wildlife production (NED)			Average annual net increase $6,540,000 (2,3,5,9)
b. Preserve and restore wetlands, enhance vegetative growth, establish favorable salinity gradients, improve sport fishing and wildlife opportunities			Positive contribution-reduce land loss, enhance vegetative growth. Maintain favorable salinity gradients. Decrease loss of recreational opportunities (2,4,5,9)
2. Net Effects			
a. Net NED average annual benefits			$1,215,300
b. Net EQ effects			Highly positive

TABLE B 3-2

Summary Presentation And Assessment of Bonnet Carre' Plan

	Existing Conditions	Future Conditions (No-Action) 2035	Plan 1
I. PLAN DESCRIPTION			Bonnet Carre' freshwater diversion structure capable of diverting 30,000 cfs during 50% drought conditions. Diversion Period-March-November. Recreation facilities developed at lower end of floodway. Frenier Beach, the Rigolets, Pointe Au Herbes, Cedar Point and Pelt River
II. IMPACT ASSESSMENT			
1 National Economic Development			
a. Total Average Annual Benefit			$[illegible] (2,5,9)
Fish and wildlife			[illegible]
Recreation			[illegible]
Sport Fishing and Hunting			[illegible],000
b. Total Average Annual Costs			
(1) Interest and Amortization			$[illegible] (1,5,9)
(2) Operation and Maintenance			818,000 (2,3,5,9)
c. First Cost			$[illegible] (1,5,9)
d. Net Annual NED			
e. Benefit Cost Ratio			1.25
2. Environmental Quality*			
a. Wetlands	234,131 acres of marsh and 133,071 acres of wooded swamp	172,071 acres of marsh and 69,525 acres of wooded swamp	618 acres of wooded swamp and 63 acres scrub shrub affected by construction. 30,500 acres of marsh and wooded swamp saved (1,2,3,5,9)
b. Water Quality	Mississippi River Water - cool high sediment levels, toxic trace metals, nutrients, fecal coliform counts exceed marine water criteria. Receiving waters warm, moderate quality, fresh to brackish	Mississippi River stay same. Expected water quality degradation in basins, seasonal saltwater intrusions into marshes adjacent to Lakes Pontchartrain and Maurepas	divert into fresh to brackish water lake, possible bioaccumulation pollutants, favorable salinity condition established in study areas (3,4,9)
c. Endangered and Threatened Species	The bald eagle, brown pelican, Artic peregrine falcon, red cockaded woodpecker, and Mississippi sandhill crane are known to occur in study area.	These endangered species adversely affected by habitat deterioration	None affected by project
d. Fish and Wildlife	$52,800,000, total income 909,137 Man-days of hunting 1,822,781 man-days of sport fishing	Total Fish and Wildlife income decline significantly. Loss to hunting valued at $1,000,000 annually.	Significantly reduce decline in total fish and wildlife income (2,3,5,9)
e. Historic and Cultural Properties	Eight National Register properties	Properties adversely affected by natural and human induced processes wavewash subsidence, and urban and industrial expansion.	Preservation of properties by the reduction of erosion and subsidence in in project affected areas (2,3,5,9)
f. Prime and Unique Farmland and other Lands	Sugarcane, soybeans, cotton, citrus, and pecan crops grown in study areas.	Agricultural lands adversely affected by continued urbanization	None affected by project
g. Air Quality	Air quality adversely affected by industries	Continued air quality degradation in future	No effect on air quality
h. Flood Plains	Most of study area is below 5' contour	Most of study area below 5'contour	No flooding would be caused by this project
i. Wild and Scenic Rivers	Blind and West Pearl Rivers, Bayou Trepagnier, Bayou La Branche, Bayou Dupre, Lake Borgne Canal, Bashman Bayou, Terre Beau Bayou Pirogue Bayou, Bayou Bienvenue, Bayou Chaperon, and Holmes Bayou	Bayous and rivers subjected to erosion, subsidence, and wave wash	No wild or scenic rivers affected by this project

TABLE B-3-1

BONNET CARRE' PLAN

Pertinent Engineering Characteristics and Costs

Inflow Channel			Control Structure			
Bottom Elevation	Bottom Width (feet)	Length	Invert Elevation	Box Culvert No.	Size (feet)	Length
-21 NGVD	400	950	-21 NGVD	4	20'X20'	455

Outflow Channel			Land Required (Acres)			
Bottom Elevation	Bottom Width (feet)	Length	Structure & Channel	Levee	Temporary Disposal	Road
-21 NGVD	400	33,800	41.6	13.9	1460	5.7

Excavated Material (cubic yards)		Relocations Required			
Construction	Maintenance	Road	Railroads	Pipe-lines	Public Utilities
11,965,000	167,000	2	3	6	5

Cost			Real Estate Relocations	
First Cost	Annual Charge ($1,000)	Operation & Maintenance Cost	Additional Land	Structures
$57,814		$822	16 acres	69

Source: US Army Corps of Engineers, New Orleans District

be confined to the trap. The sediment trap would be placed about 3,500 feet downstream of the diversion structure. The bottom width of the trap would be 780 feet at elevation -36.0 feet with 1V on 3H side slopes to elevation -21.0 feet. The length of the trap is 1,450 feet. The top width of the channel is 1,020 feet at elevation 4.0 feet.

B.3.9. The plan would require relocating 52 single family dwellings, 16 trailers, and 1 church. Six pipelines, 5 public utilities, 2 roads, and 3 railroad trestles would be affected by the channel and structure.

B.3.10. At the lake end of the borrow channel, recreation facilities would be developed including a two-lane boat ramp, courtesy piers, parking area for 30 vehicles, 5 picnic tables, and trash cans. Similar facilities would be developed at Frenier Beach, the Rigolets, and Point Aux Herbes in Louisiana; and at Cedar Point and Wolf River in Mississippi. Each recreation development would be approximately two acres. Additional sites for recreation development would be considered in the advanced engineering and design phase of the study. A typical recreation site development plan is shown on figure G-3-1 of Appendix G, Recreation Resources.

B.3.11. Pertinent cost and design data including dimensions of the control structure and inflow and outflow channels, land requirements, amount of excavated material, and required relocations are shown in table B-3-1. Detailed information on the estimated costs is in Appendix C, Engineering Investigations. The beneficial and adverse impacts of the plan are displayed in table B-3-2.

Pontchartrain. In the floodway, excavated material would be placed adjacent to the diversion channel 3 to 4 feet high to be removed by sand haulers. The excavated material would be used as fill for construction activities in the surrounding urban areas. Sand haulers are currently allowed to remove the sandy material from the floodway. The clayey material would be used in levee construction and in sanitary landfill in the area. The excavated material would be removed from the floodway in order to maintain the capacity for flood control.

B.3.6. The diversion channel through the floodway would sever access roads used by sand haulers. A timber bridge would be provided across the diversion channel just above the Illinois Central Gulf railroad to give sand haulers continued access into and out of the floodway. The timber bridge would be capable of withstanding spillway openings.

B.3.7. The upper guide levee would be realined outside the Federal rights-of-way to enclose the diversion channel and structure within the floodway. The realinement would provide flood protection for surrounding residents from overflow of floodwaters diverted through the Bonnet Carre' floodway. Although the diversion channel would be designed to contain all flows within banks, an added factor of safety would be provided by enclosing it within the floodway. About 3,035 feet of upper guide levee 12 to 16 feet high with sideslopes of 1V to 5.5H would be constructed on the protected side and 1V to 3.5H on the floodside. The realined levee would be tied into the Mississippi River levee. About 1,250 feet of the Mississippi River levee would be realined over the diversion structure, the levee would be about 26 feet high with side slopes of 1V on 5.5H on the riverside and 1V on 4H on the land side.

B.3.8. The sediment trap is designed to contain the sand load in the diverted river water. Most of the channel maintenance, therefore, would

diminish the blue crab, speckled trout, and sheepshead catch.

The 5 ppt line would be nearer the 15 ppt isohaline than it is now and the extent of 5-15 ppt area would be compressed if an attempt were made to attain the Ford line. The amount of desirable habitat would be reduced. All these adverse biological impacts would be reflected as economic losses. Since economic justification of the project is uncertain, it certainly could not stand such losses.

An extensive discussion ensued after the presentation. The general consensus of the group was that new positions of the Ford and Palmisano lines should be established. It was agreed that the study area would be managed primarily for oysters recognizing that benefits would also accrue to other estuarine species. A subcommittee composed of the Corps of Engineers, Louisiana Department of Wildlife and Fisheries, Department of Natural Resources, National Marine Fisheries Service, Mississippi Bureau of Marine Resources, and US Fish and Wildlife Service was organized. The subcommittee will meet in Baton Rouge at 9:00 a.m. on 22 and 23 June 1982 at the Louisiana Wildlife and Fisheries Building to determine new locations of isohalines. The ad hoc group will meet at 9:00 a.m. on 24 June 1982 at the Wildlife and Fisheries Building to review and evaluate subcommittee recommendations for new positions of isohalines. The discussion is summarized in the following paragraphs.

Mr. Donald Moore. How would the isohalines in Mississippi be affected by the freshwater diversion?

Falcolm Hull. Analyses show that to significantly change the isohalines in Mississippi would require massive amounts of freshwater that would make the estuarine areas in Louisiana far too fresh. It was concluded and so stated in the reconnaissance report that isohalines in Mississippi would not be significantly affected. However, increases in the production of fisheries in Louisiana would result in increase in fisheries in Mississippi because a large portion of the fisheries catch in Mississippi depends on Louisiana marshes.

Ted Ford. How would the freshwater get across the Mississippi River-Gulf Outlet (MR-GO)?

Burnell Thibodeaux and Jay Combe. It is estimated that about 50 percent of the water would go across the MR-GO. The remaining water would go up or down the MR-GO depending on tides and would overflow into the adjacent marshes.

Barney Barrett. What affect would the reduction in Mississippi River flow due to diverting water to the Lake Pontchartrain-Borgne Basin have on the influence of the Mississippi River on the Barataria Basin?

Falcolm Hull. The affect would be insignificant since we would be diverting less than 10 percent of the Mississippi River flow during low flow conditions. In addition, we are recommending that a freshwater diversion project be built for the Barataria Basin.

Chuck Killebrew and Donald Moore. Why do the projects in the Pontchartrain-Borgne Basin cost more than the projects in the Louisiana Coastal study?

Jay Combe. Conveyance channel requirements are significantly larger and

longer. Supplemental water requirements are greater and require larger diversion structures.

Ted Ford. When the Ford line was drawn, it was envisioned that freshwater diversion would be controlled and would occurr for a few months during the period when the Mississippi River overbank flooding historically influenced the area. This period was generally January through April and, on occasion, May and June. It was never the intention to have year-round diversion or even to maintain the Ford line for a prolonged period of time.

David Chambers. At what river stage would the structure be incapable of passing freshwater?

Falcolm Hull. The structures are designed to maintain desirable salinity conditions in the marshes during a drought that has a frequency of occurrence of once in ten years. The structures are capable of passing flows from a maximum of 24,600-30,000 cfs January through April to a low of about 5,000 to 13,000 cfs in August or September.

Barney Barrett and Donald Moore. Did benefit calculations include any benefits to Mississippi?

Falcolm Hull. Because isohalines in Mississippi would not be significantly affected, benefits could not be computed. However, the increase in commerical fisheries catch that results from reduced marsh loss would be considered when detailed computations of benefits are made.

Donald Moore. Identifiable benefits to the Mississippi as well as the Louisiana fisheries should be fully considered. Mississippi Congressman Trent Lott was one of the prime movers in getting the study initiated.

Suzanne Hawes. There would be benefits to Mississippi due to the addition of nutrients to the area, but these benefits cannot be uantified at this time.

Ted Ford. Conditions in the Lake Pontchartrain-Borgne Basin have changed since the Ford line was drawn. The western end of Lake Borgne is closed to oyster harvesting. Efforts are being made to discourage leasing in Lake Borgne. A compromise can be achieved if study objectives are modified. But in any case, freshwater diversion should stop around April. A plan could be developed that is cost effective, minimizes losses, and maintains reasonable levels of fish and wildlife productivity.

Donald Moore. Sizable benefits ought to be identifiable from the white shrimp that could offset losses to some or all of the oysters in Lake Borgne. Valuable information could be obtained from the study conducted by the Galveston District for the mouth of Colorado River, Texas.

David Fruge'. He explained the method used to compute benefits in the Louisiana Coastal Area study and indicated that the report prepared by the Galveston District had been reviewed.

Mark Chatry. Oyster populations are more adversely affected in late summer. At this time, oysters are setting and most vulnerable to predation. Freshwater diversion January through April may not have any significant

benefits in terms of desirable salinity.

Van Beek. The analysis Van Beek performed for the Department of Natural Resources, Coastal Management, supported the Corps analysis. Freshwater diversion earlier in the year would not have a measurable effect on salinity in the latter part of the year. The predation problem in oysters would not significantly be affected. There is a strong relationship between salinity no matter how much water is diverted.

John Weber. Criteria should be established for identifying the new positions of the isohalines.

Dave Fruge'. One of the criteria should be that the 5 ppt isohaline not be pushed out of Lake Borgne.

Barney Barrett. Salinity below 5 ppt on an intermittent basis would not adversely affect oysters. The isohalines should be allowed to oscillate.

Falcolm Hull. If isohalines are allowed to move, benefits cannot be calculated.

Chuck Killebrew. Flexibility is essential in the management scheme of a freshwater diversion project.

John Weber. A subcommittee should be created to identify the location of the new isohalines and report back to ad hoc group. Work of the group should be completed by the end of June 1982 so that the study can stay on schedule.

Mark Chatry. We should investigate areas with established reefs. Lake Borgne already has established reefs. The marsh areas would mostly benefit from attaining the Ford line where the number of reefs may be limited.

Ted Ford. The area west of Proctor Point in Lake Borgne is closed to oyster harvest and probably will not be leased anymore.

Dave Fruge'. The 5 ppt isohaline should be placed in the middle of Lake Borgne.

Mark Chatry. We would be trading Lake Borgne for areas that are more seaward. Reef acreage should be plotted to determine how much of the area is actively suitable for oyster production.

Dave Fruge'. What salinities are required to prevent predation and how long are these salinities required?

Mark Chatry. Based on data from the Bay Gardene, Black Bay, and California Bay areas, salinities should be reduced in April to 5-10 ppt and kept below 15 ppt until around August or September. It does not seem to matter how high salinities get after September.

John Weber. How long does it take for the predators to move back into oyster growing areas after salinities are reduced and allowed to increase above 15 ppt?

Mark Chatry. We don't have that information, but will investigate before the subcommittee meeting.

John Weber. The State Health Department could not send a representative to this meeting. They did send a letter to be read at the meeting. In the letter they indicated their support for freshwater diversion, but cautioned that oyster bottoms are closed when state standards for fecal coliform are exceeded.

MISSISSIPPI AND LOUISIANA ESTUARINE AREAS STUDY

Ad Hoc Group Meeting

24 June 1982

The ad hoc group meeting was held on 24 June 1982 at 9:00 a.m. in Baton Rouge, Louisiana, at the Louisiana Department of Wildlife and Fisheries building. Attendees and the agencies represented are listed below:

Name	Agency
Mark Chatry	Louisiana Department of Wildlife and Fisheries
Falcolm Hull	US Army Corps of Engineers
John Weber	US Army Corps of Engineers
J. R. Herring	Mississippi Department of Wildlife Conservation, Bureau of Marine Resources
Victor L. Casper	US Food and Drug Administration, Dallas, Texas
Walter Morse	Louisiana Department of Health and Human Resources, New Orleans, LA
Robert Buisson, Jr.	US Army Corps of Engineers
Dennis Chew	US Army Corps of Engineers
Richard Condrey	Center of Wetland Resources, LSU, Baton Rouge, LA
Barney Barrett	Louisiana Department of Wildlife and Fisheries
McFadden Duffy	Louisiana Department of Wildlife and Fisheries

The purpose of the meeting was to present the subcommittee recommendations for new positions of isohalines that would establish desirable salinity conditions in the Lakes Pontchartrain-Borgne Basin. The subcommittee met on 22 and 23 June 1982 and reached a consensus on desirable salinity conditions for enhancing fish and wildlife resources in the basin. Several members who participated in the subcommittee work session were unable to attend the ad hoc group meeting due to other commitments. Mr. Falcolm Hull briefed the group on the study status and the first ad hoc group meeting. Messrs. Dennis Chew and Mark Chatry presented the subcommittee conclusions and recommendations. They are:

o Desirable salinity conditions would exist for most of the months during a 10-percent drought in the Lake Borgne area, based on hydrologic data presented by the Corps of Engineers. Very few benefits would accrue from managing the Lake Pontchartrain-Borgne Basin for oyster production in Lake Borgne. The area is marginal for oyster production and the quality of oysters produced in

[illegible] not very good.

[illegible] desirable salinity regime should be reestablished on the natural oyster reefs along the seaward fringes of the St. Bernard Parish marshes. This location approximates the position of the Ford line established by the ad hoc group in 1970. However, rather than attempt to constantly maintain salinities at [illegible] ppt the Ford line, the group has determined that it would be more desirable if the salinities are allowed to vary as they did under historical conditions that [illegible]ed with the overbank flooding of the Mississippi River. Different mean monthly salinities would be maintained. This determination is based on recent Louisiana Department of Wildlife and Fisheries studies of success in seed oyster production. The desirable salinity regime should be analyzed for several locations starting at the original location of the Ford line and moving inland toward Lake Borgne. This analysis may enhance the prospects of developing an implementable, economically feasible, and environmentally acceptable plan. The Palmisano line would be met if optimum salinity conditions are maintained for oysters.

o The diversion structures should be designed to establish the desirable salinity regime for 4 or 5 years in a 10-year period. Past experience of the Louisiana Department of Wildlife and Fisheries marine biologists indicates that if good seed oyster production is obtained 4 or 5 years in 10, the oystermen would have more than enough oysters to significantly expand the industry.

o During periods of freshwater diversion into the basin, the brown shrimp, spotted seatrout, red drum, and other estuarine species less tolerant of low salinity may be displaced seaward. However, the beneficial effects of the freshwater should result in increased populations of these species in subsequent years.

o The ad hoc group fully supports the Corps of Engineers efforts in developing a freshwater diversion project for the Lake Pontchartrain-Borgne Basin and recommends that the ad hoc group be used as basis of the public involvement program. The ad hoc group is willing to participate in meetings and workshops, and to contact parish and local officials and special interest groups in an effort to establish public support for the project.

Messrs. Casper and Morse supported the conclusions and recommendations of the subcommittee. They noted that from a water quality standpoint Lake Borgne is marginal. They added that the oysters harvested from Lake Borgne are poor quality and very few oystermen actually harvest oysters in the lake. They stated that they were aware that the reefs existed and that a freshwater diversion project would be beneficial overall. Mr. Morse indicated that the few oystermen who use Lake Borgne would oppose the project and these individuals are influential in St. Bernard Parish. Mr. Casper indicated that additional patrolling and enforcement of state shellfish standards would be required if the reef acreages were put back into production.

Mr. Robert Buisson discussed public acceptance of a freshwater diversion project based on the subcommittee recommendations. He indicated that sportfishermen would voice opposition. Sport shrimpers are having an excellent brown season shrimp season in Lake Pontchartrain this year. Under the proposed diversion project, freshwater would displace estuarine species,

moving the shrimp gulfward. Unless agencies that have an interest in fish and wildlife resources actively participate in supporting the project, the Corps probably will not be successful in constructing a freshwater diversion project in the Lake Pontchartrain-Borgne Basin. These agencies, working on a day-to-day basis with the people who would be affected by the project, should be able to communicate the benefits of the project to them. The agencies should participate with the Corps in public meetings on the proposed project to clearly demonstrate their full support. Messrs. Buisson and Weber questioned whether other alternative salinity regimes could be identified that might produce substantial benefits with fewer adverse impacts. They stressed that it is important to identify and consider any other possible alternatives in the reanalysis. The subcommittee agreed that the proposed salinity regime is the optimum regime and the location could be varied to bring into production less than the maximum 12,000 acres of reefs if the reanalysis shows a substantial reduction in adverse impacts. The subcommittee indicated that the proposed regime would be highly desirable, that they would support it, and that further study would not produce any other alternatives.

After a discussion of the subcommittee recommendations, the ad hoc group agreed that the Corps should use these recommendations in developing a freshwater diversion project for the Lake Pontchartrain-Borgne Basin. The meeting adjourned at 12:30.

MEMORANDUM FOR RECORD

MISSISSIPPI AND LOUISIANA ESTUARINE AREAS STUDY

AD HOC INTERAGENCY GROUP SUBCOMMITTEE RECOMMENDATIONS

22-23 June 1982

At the ad hoc interagency group meeting on 28 May 1982, the findings from the analyses performed to date on the Corps study were presented. The difficulty of achieving the study objectives--the Ford line, April through September, and Palmisano line, October through March--was discussed. Based on information given at the meeting, the group agreed that the positions of the Ford and Palmisano lines should be reconsidered. A subcommittee composed of the US Army Corps of Engineers, Louisiana Department of Wildlife and Fisheries and the Department of Natural Resources, National Marine Fisheries Service, Mississippi Department of Wildlife Conservation, the Bureau of Marine Resources, and the US Fish and Wildlife Service was organized. The subcommittee is to review available pertinent information and develop objectives for enhancing fish and wildlife resources through freshwater diversion. The subcommittee would prepare the rationale for the objectives and the justification for deviating from the existing Ford and Palmisano 15 ppt isohalines. The subcommittee met in Baton Rouge on 22 and 23 June 1982 at the Louisiana Department of Wildlife and Fisheries building. Persons who participated in the subcommittee meeting and the agencies they represented are listed below:

Name	Agency
David Fruge'	US Fish and Wildlife Service
Gerald Bodin	US Fish and Wildife Service
Mark Chatry	La. Department of Wildlife and Fisheries
Chuck Killebrew	La. Department of Wildlife and Fisheries
Donald Moore	National Marine Fisheries Service
Falcolm Hull	US Army Corps of Engineers
Jay Combe	US Army Corps of Engineers
Burnell Thibodeaux	US Army Corps of Engineers
B. J. Garrett	US Army Corps of Engineers
Dennis Chew	US Army Corps of Engineers
J. R. Herring	Mississippi Department of Wildlife Conservation, Bureau of Marine Resources
David Chambers	Coastal Management/DNR
Johannes Van Beek	Coastal Management/DNR (Consultant)
Barney Barrett	La. Department of Wildlife and Fisheries
*Robert Buisson, Jr.	US Army Corps of Engineers
*John C. Weber	US Army Corps of Engineers

*Participated in the 23 June 1982 afternoon work session.

Mr. Dennis Chew opened the meeting by reviewing the information presented at the ad hoc group meeting on 28 May 1982 and restating the objective of the subcommittee. Mr. Hull presented hydrologic information developed for the study after the last meeting. He stated that diverting 100 percent of flow year round at the structure designed for the proposed Bonnet Carre' site would maintain the Ford line only from April through June. The 15 ppt isohaline would gradually move inland through July, August, and September. During October through March, the Palmisano line could be maintained. By diverting 100 percent of flow at the Lake Borgne site or diverting flow at both of the sites, the desired salinities could generally be maintained from January through May and October through December. The average position of the 15 ppt isohaline for post-Mississippi River-Gulf Outlet (MR-GO) conditions was just west of the Ford line in the St. Bernard marshes. The average position of the 5 ppt was along the eastern edge of Lake Pontchartrain. The average position of the 15 ppt isohaline for a 10-percent drought would be southeast of Lake Borgne about halfway between Lake Borgne and the Ford line. The position of the 15 ppt isohaline would move inland only slightly for a 10-percent drought in the year 2035. Several of the subcommittee members questioned the 15 ppt isohaline moving inland only slightly over the next 50 years. Mr. Combe explained that after the MR-GO was completed, salinities increased. However, an analysis of data indicates that salinities in the study area have not increased significantly in recent years and have stabilized since the construction of the MR-GO. Mr. Thibodaux stated that although land loss is occurring in the area as a result of subsidence, compaction, and erosion, the newly created open water areas are shallow and do not lend themselves easily to saltwater intrusion. Mr. Johannes Van Beek added that this is probably true if the marsh is a small percentage of the tidal prism. The marsh may not be important from a hydrologic viewpoint but it is very important from a biological viewpoint.

A review of the 15 ppt isohaline on a monthly basis for the 10-percent drought conditions indicates that the isohaline approximates the Ford line from January through April, moves gradually toward Lake Borgne from May through November, and begins to move seaward in December. The 15 ppt isohaline reaches the eastern shore of Lake Borgne in August. The 5 ppt isohaline would be along the northern shore of Lake Borgne in January, would move into Lake Pontchartrain in June, and to about the causeway (halfway across the lake) by September. Mr. Chew noted that the salinities shown for the 10-percent drought conditions were desirable for oyster production in Lake Borgne and it did not appear that a significant amount of supplemental flow would be required even during a 10-percent drought condition.

Mr. Mark Chatry suggested that salinity conditions similar to those that existed in the Breton Sound area preceeding peak seed oyster production years should be sought for the Lakes Pontchartrain-Borgne Basin. He explained that seed oysters are the limiting factors in oyster production in Louisiana. About 70-80 percent of all oysters produced in Louisiana have their origin on the state seed grounds. The prime seed grounds are presently located at the southern end of Breton Sound Basin. Oystermen usually enter the seed grounds during September, October, and November to dredge for the small seed oysters (1" to 3"). The seed oysters are then transferred to leased water bottoms until they grow to a size suitable for market. If oyster production is going to be significantly increased, consistently high levels of seed oyster

production must be maintained. It was indicated that a large portion of the formerly productive public oyster seed grounds is located in St. Bernard Parish along the fringes of the marshes in Chandeleur Sound.

In the discussion, a number of salient facts regarding oyster production in the area were identified. There are approximately 51,000 acres of private leases east of the MR-GO, 19,000 acres in Lake Borgne, and 32,000 within the Louisiana Marsh. There are about 250,000 acres of public seed grounds in the area along the fringes of the Louisiana Marsh. There is no data available on total private leases versus potentially productive private lease acreage. Potentially productive lease acreage is on water bottoms with suitable substrate. An area with suitable substrate is productive only if salinities are favorable. Data is available on potentially productive acreage on the public seed grounds in the form of surveys conducted by Captain Baldo Pausina. He estimated that there are 12,000 acres of suitable substrate on the public seed grounds east of the MR-GO.

The area of the Pontchartrain-Borgne Basin with both suitable salinities and substrate for oyster production has decreased 60-80% in recent years due to increased salinities. At present, suitable salinities are confined mostly to the Lake Borgne area. The Louisiana Department of Wildlife & Fisheries, however, has instituted a moratorium on new leases in Lake Borgne at the request of the Department of Health and Human Resources because of the marginal quality of water in Lake Borgne.

Mr. Chatry stated that if desirable salinity conditions are reestablished in the areas of the formerly productive public oyster seed grounds along the fringes of the St. Bernard marshes, currently unproductive portions of the 12,000 acres of reefs could be brought into the production of seed oysters and oysters suitable for marketing.

A recent study conducted by the Louisiana Department of Wildlife and Fisheries identified optimum mean monthly salinities for oysters based on data collection at three stations in Louisiana's most productive seed grounds. The data was collected over a 10-year period, 1971-1981. Salinity data and seed oyster production data were analyzed to determine optimum salinity conditions. The resulting optimum monthly salinity regime is shown in the attachment. The optimum salinity regime is considered to mimic salinity conditions that existed when the Mississippi River overflowed its banks during the early part of the year. It was the consensus that mean monthly salinities should be maintained at the location of the Ford line as shown in the chart.

Month	Mean Optimum Salinity (ppt)	Standard Error
January	16.4	1.04
February	14.4	0.79
March	11.6	1.02
April	8.0	1.27
May	7.0	0.92
June	12.5	0.80
July	12.7	0.57
August	15.7	0.80
September	17.0	1.06
October	16.8	0.87
November	16.1	0.82
December	15.7	0.52

The optimum salinity regime allows salinities at the Ford line to vary rather than attempting to constantly maintain them at 15 ppt at that location. The average salinity from April through September would be about 12 ppt and from October through March, 15 ppt. At the 28 May 1982 ad hoc group meeting, Dr. Ted Ford, after whom the Ford line was named, indicated that when the line was drawn he did not intend that the line be maintained for a prolonged period of time. He envisioned that freshwater would be diverted for a few months during the period when the Mississippi River overbank flooding historically influenced the area. This period was generally from January through April and, on occasion, May and June.

If a good crop of seed oysters is produced 1 out of 2 or 3 years on the average, then the amount of oysters produced would more than sustain a significant expansion in the oyster industry. Therefore, the structures should be designed for diversion of sufficient freshwater to establish this salinity regime 4 or 5 years in 10.

Messrs. Combe and Thibodaux made a cursory review of the optimum salinity regime and determined that a structure designed to divert flow at the Bonnet Carre' site could probably maintain the desired salinity regime within the standard error (see attached) with diversions from January through July. It appears that the structure would be designed for the 50-percent drought condition. Further hydrologic analysis would be required to determine whether the structure, as designed, would divert sufficient freshwater to establish the desired salinity regime without year-round diversion.

Several members of the subcommittee expressed concern that the optimum salinity regime for oysters will have an adverse impact on shrimp, crabs, menhaden, and other estuarine species. Mr. Barney Barrett indicated that Lakes Pontchartrain and Borgne are very popular sport shrimp harvest locations. Commercial harvest from Lakes Pontchartrain and Borgne is very small compared to the total state shrimp harvest. He noted that in historically wet years or years when freshwater was diverted through Bonnet Carre' Spillway, there have been low shrimp populations in the lake. Everyone acknowledged that during years when water would be diverted into Lake Pontchartrain, the brown shrimp population that generally moves into the lake in March and April would probably be displaced to Lake Borgne and the surrounding bays and sounds. White shrimp populations that usually move into the lake in mid-summer (June, July, and August) would not be significantly

affected because they are more tolerant of a low salinity environment. The difference in temperature of lake and river water would not be a factor because the temperatures are usually within two or three degrees of each other at this time of year. Other species that prefer higher salinity waters such as spotted seatrout and red drum may be displaced from Lake Pontchartrain during years of freshwater diversion. Populations of crabs, menhaden, catfish, and shad would probably increase during years of freshwater diversion. Generally, one or two years subsequent to Bonnet Carre' Spillway openings, shrimp and other estuarine species have been found in greater abundance. The nutrients contained in the freshwater stimulate plant and animal growth.

Wildlife would probably benefit from freshwater introduction because some of the brackish marshes around Lake Pontchartrain may be converted to fresher types preferred by wildlife. The sediments and nutrients contained in the freshwater would result in healthier marshes and reduce the land loss rate.

In a discussion of public acceptance of a freshwater diversion project, several areas of concern were indicated by one or more participants.

o Some sport fishermen who use Lakes Pontchartrain and Borgne may oppose the proposed project if they believe their catches will be affected.

o Some oyster fishermen in Lake Borgne may be adversely affected by freshwater diversion. Attempts will be made to minimize potential adverse impacts.

o Some local interests may oppose the freshwater diversion project in parishes where the diversion sites are located. St. Bernard parish has already identified a need for some modifications at the diversion site in their parish.

o Other parishes on the lake concerned about flooding may voice some objections. An analysis should be conducted to determine the impact, if any, that freshwater introduction may have on the lake water level so that the concerns about flooding can be adequately addressed.

o The pollutants contained in the Mississippi River may cause some persons to oppose the project. The water quality implications of diverting freshwater to the Lakes Pontchartrain-Borgne Basin would be addressed in the water quality appendix and Environmental Impact Statement of the study report. In addition, the proposed s ructure near Caernarvon to divert water into the Breton Sound Basin would probably be built first. As part of the Caernarvon project, there is an extensive pre-project and post-project water quality and biological monitoring program that would provide valuable information on water quality impacts associated with freshwater diversion.

Some residents of St. John the Baptist, St. James, and St. Charles Parishes currently oppose the construction of a freshwater diversion structure at the Bayou Lasseigne site. State and local agencies that support the project have not been vehement enough in voicing their support. Unless agencies with an interest in fish and wildlife resources actively participate in public involvement efforts, the Corps probably will not be successful in constructing the proposed freshwater diversion project in the Lakes Pontchartrain-Borgne

[illegible]. These agencies, working on a day-to-day basis with the people who would be affected by the project, should be able to communicate the benefits of the project to the people. The agencies should participate with the Corps in public meetings on the proposed project to clearly demonstrate their full support.

All members of the subcommittee indicated that they would encourage their agencies to actively promote public acceptance of the project. It was suggested that the ad hoc group continue to meet throughout the study and act as the nucleus of the public involvement program.

The group recognizes that some adverse impacts would occur and some opposition would surface with the proposed salinity requirement. Therefore, Messrs. Boisson and Weber questioned whether other alternative salinity regimes could be identified that might produce substantial benefits with fewer impacts. They stressed that it is important to identify and consider any other possible alternatives in the reanalysis. The subcommittee agreed that the proposed salinity regime is the optimum regime and the location could be varied to bring into production less than the maximum 12,000 acres of reefs if the reanalysis shows a substantial reduction in adverse impacts. The subcommittee indicated that the proposed regime would be highly desirable, that they would support it, and that further study would not produce any other alternatives.

The subcommittee closed their work session on the afternoon of 23 June 1982 and presented the following conclusions and recommendations:

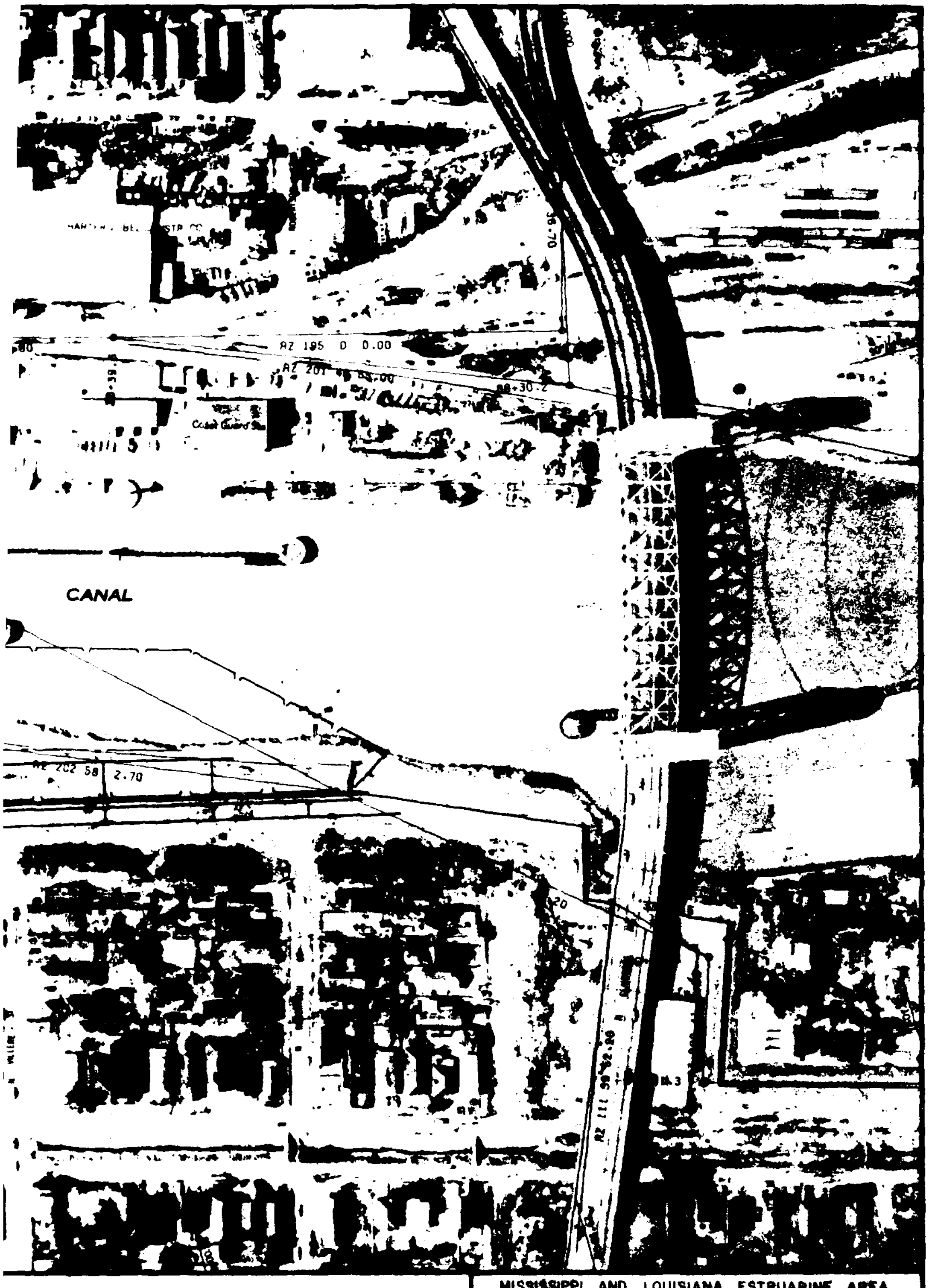
o Based on hydrologic data presented by the Corps of Engineers, desirable salinity conditions would exist during a 10-percent drought in the Lake Borgne area for most of the months. Very few benefits would accrue from managing the Lakes Pontchartrain-Borgne Basin for oyster production in Lake Borgne. The area is marginal for oyster production and the quality of oysters produced in the area is not very good.

o A desirable salinity regime should be reestablished on the natural oyster reefs along the seaward fringes of the St. Bernard Parish marshes. This location approximates the position of the Ford line established by the ad hoc group in 1976. However, based on recent Louisiana Department of Wildlife and Fisheries studies of recorded success in seed oyster production, it would be more desirable if salinities are allowed to vary as they did under the historical conditions that existed with overbank flooding of the Mississippi River. Different mean monthly salinities would be maintained. The desirable salinity regime (see attached) should be analyzed for several locations starting at the original location of the Ford line and moving inland toward Lake Borgne. This analysis may enhance the prospects of developing an implementable, economically feasible, and environmentally acceptable plan. The Palmisano line would be met if optimum salinity conditions are maintained for oysters.

o The diversion structures should be designed to establish the desirable salinity regime for 4-5 years in a 10-year period. Past experience of the Louisiana Department of Wildlife and Fisheries marine biologists indicates that if good seed oyster production is obtained 4-5 years in 10, the oystermen would have more than enough oysters to significantly expand the industry.

o During periods of freshwater diversion into the basin, the brown shrimp, spotted seatrout, red drum, and other estuarine species less tolerant of low salinity may be displaced seaward. However, the beneficial effects of nutrients in the water should result in increased populations of these species in subsequent years.

o The ad hoc group fully supports the Corps of Engineers efforts in developing a freshwater diversion project for the Lakes Pontchartrain-Borgne Basin and recommends that the ad hoc group be used as basis of the public involvement program. The ad hoc group is willing to participate in meetings and workshops, and to contact parish and local officials and special interest groups in an effort to establish public support for the project.



MISSISSIPPI AND LOUISIANA ESTRUARINE AREA

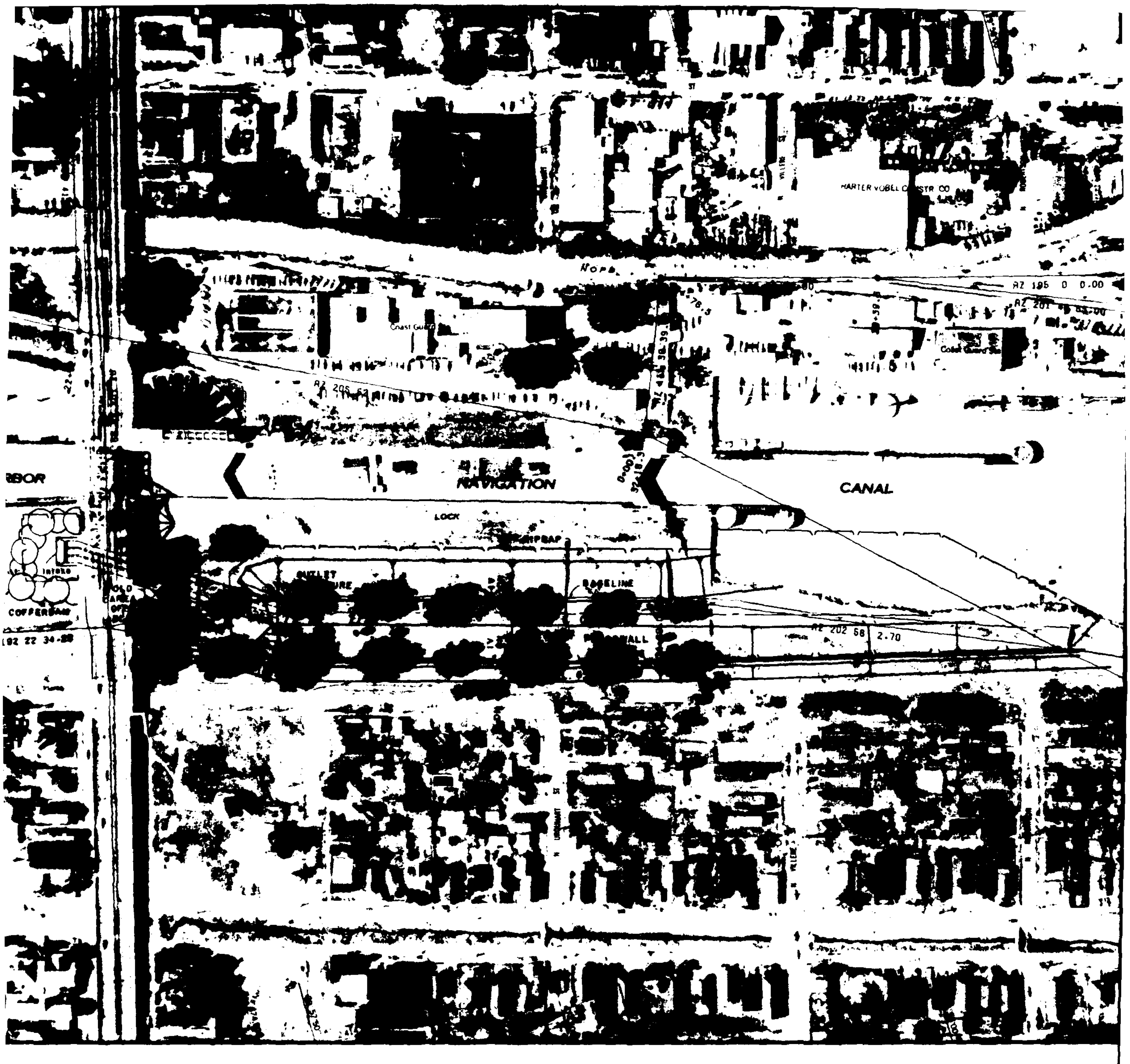
DIVERSION STRUCTURE ADJACENT TO IHNC LOCK

U S ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

3

PLATE B-8



ALE IN FEET
100 200 300

POLYCONIC PROJECTION 1927
IS SHOWN BY SOLID TICKS AND
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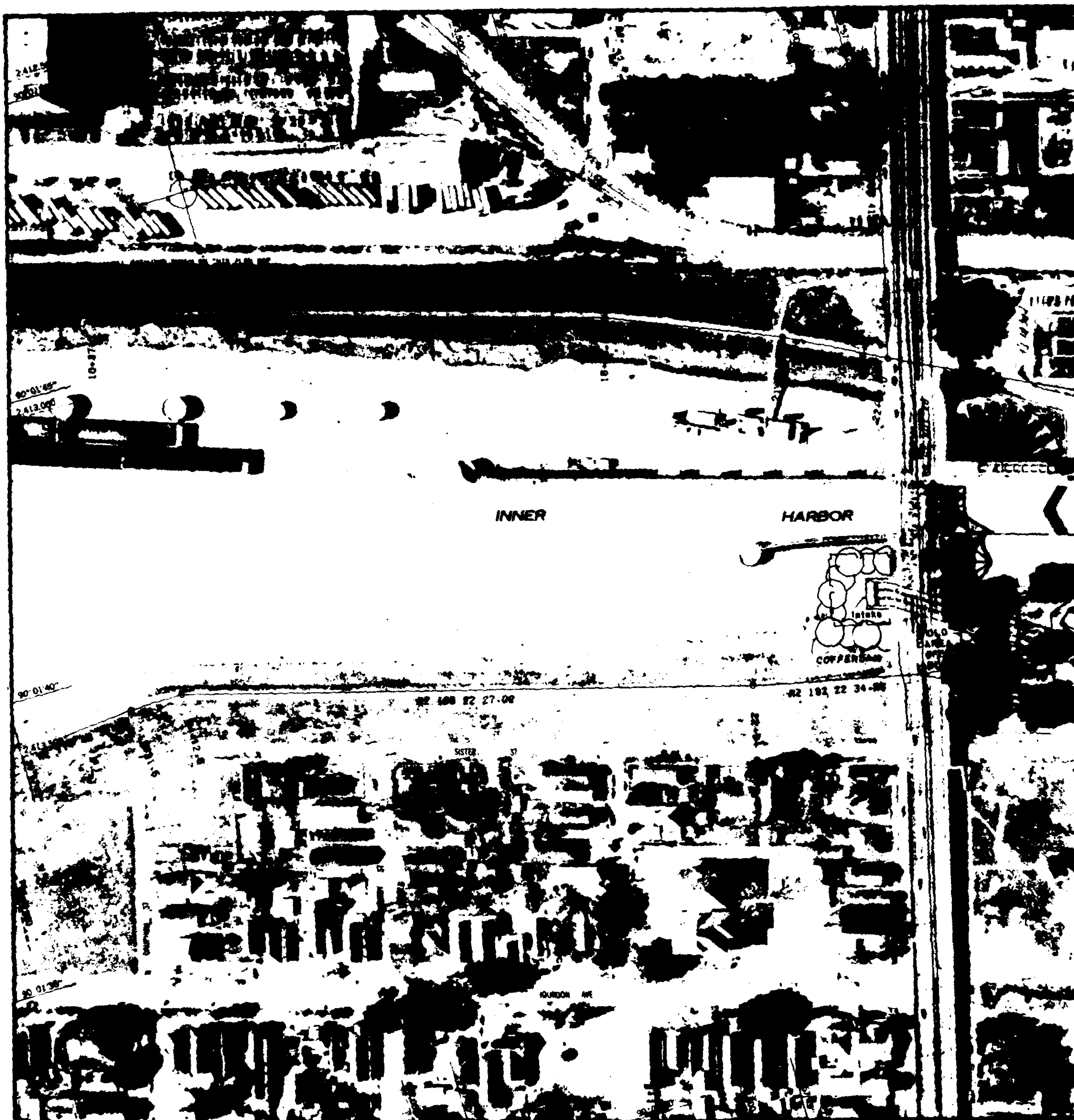
PHOTOS FLOWN JANUARY 1978

2

/



SCALE IN FEET

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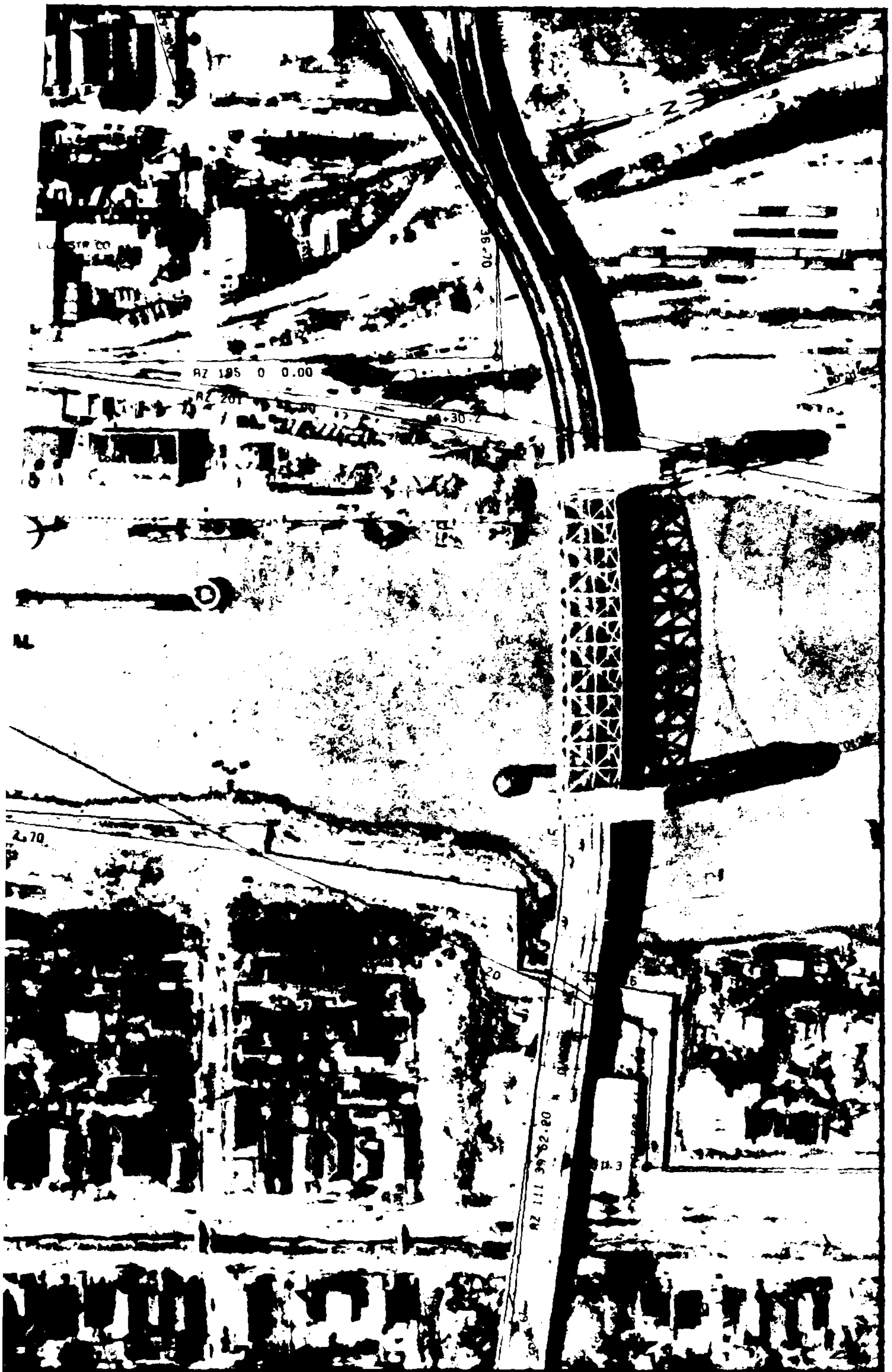
NOTES:

INSIDE THE PLAN AREA POLYCONIC PROJECTION-1927 NORTH AMERICAN DATUM IS SHOWN BY SOLID TICKS AND LAMBERT CONFORMAL CONIC PROJECTION IS SHOWN BY DASHED TICKS

PREPARED FROM AERIAL PHOTOS FLOWN JANUARY 1978

1

2



MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

INNER HARBOR NAVIGATION CANAL
SITE

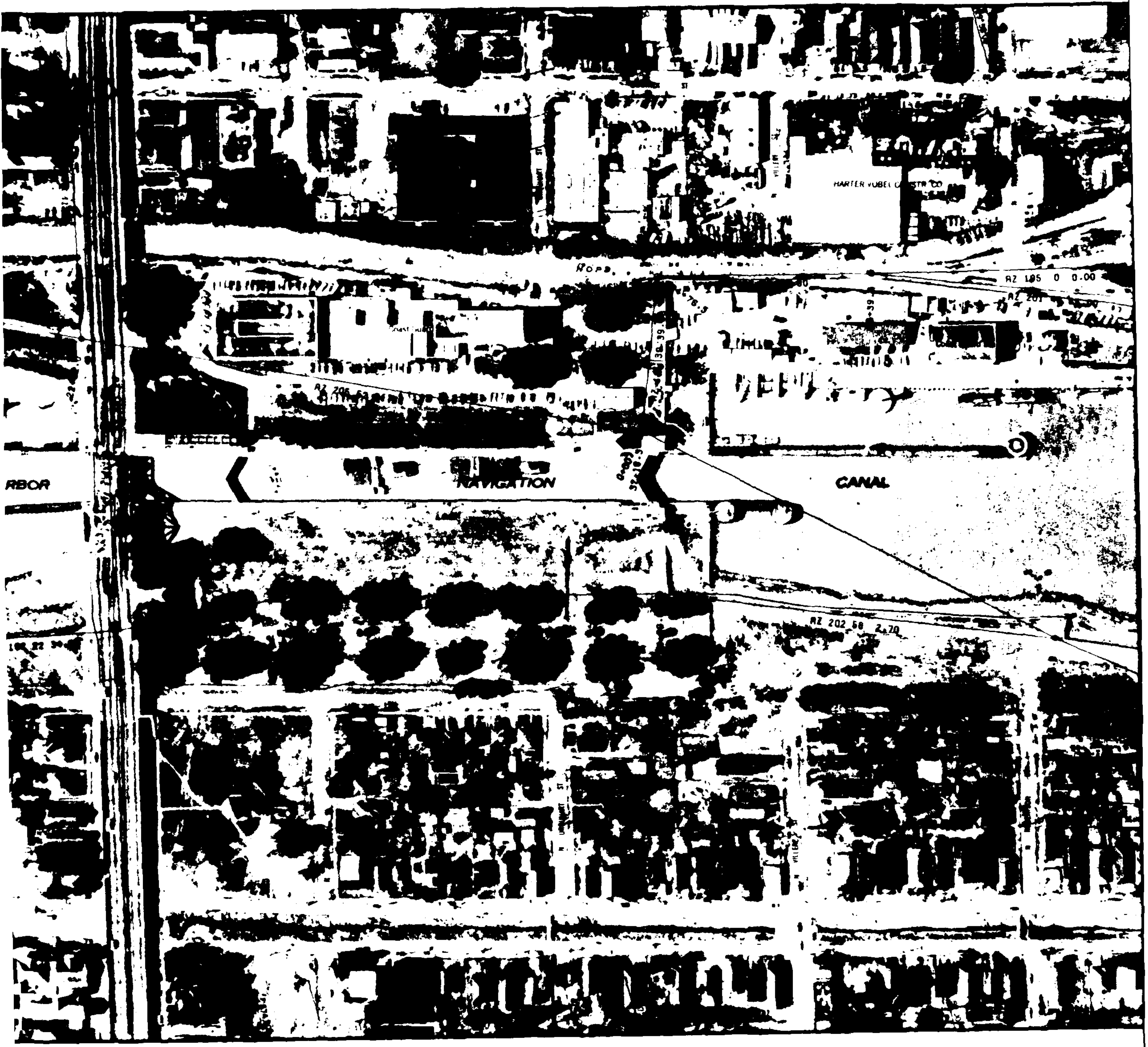
APRIL 1984

FILE NO.

3

PLATE B-7

1



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... IS SHOWN BY SOLID TICKS AND
... PROJECTION IS SHOWN BY

... PHOTOS FLOWN JANUARY 1978

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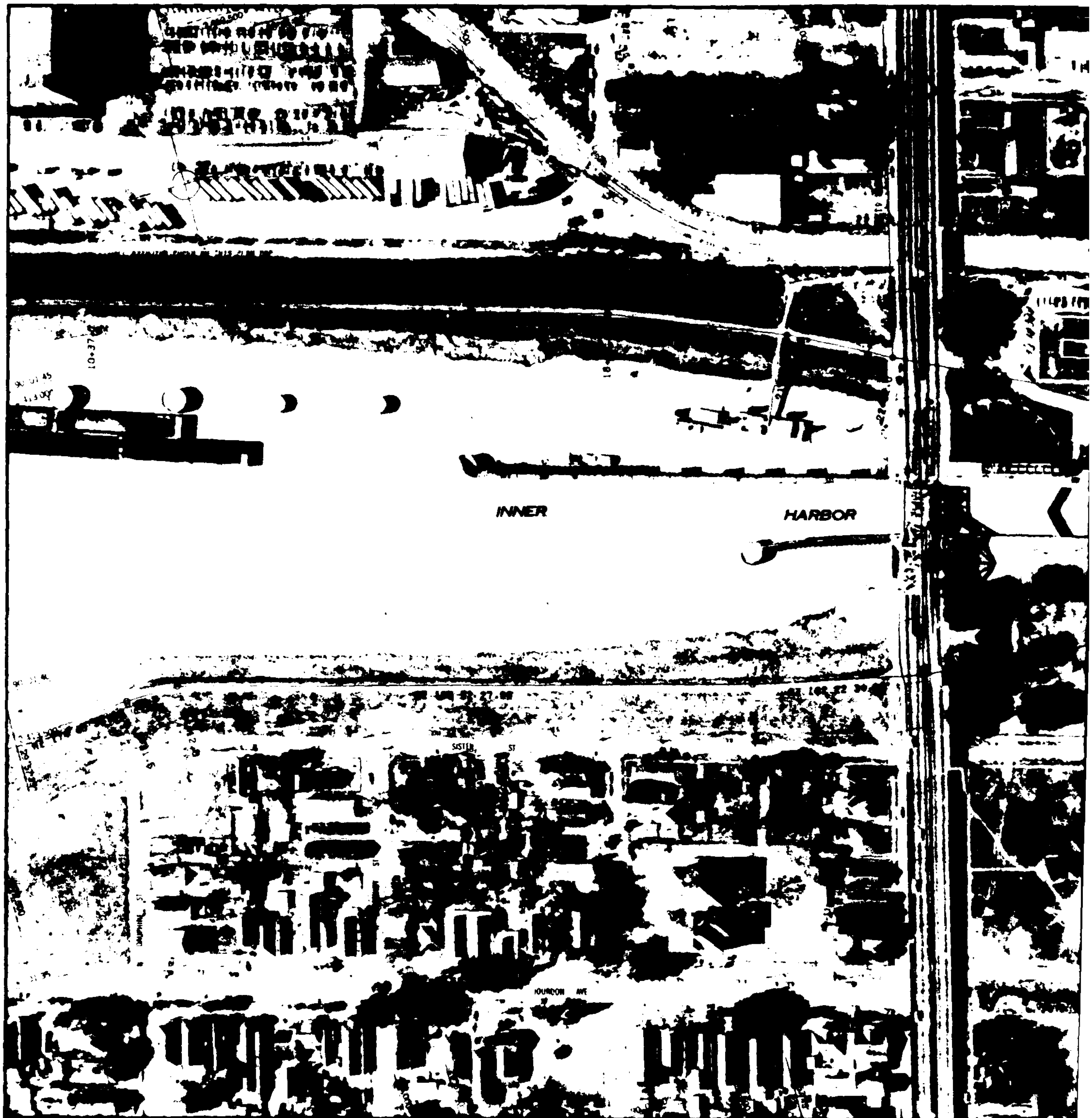

SCALE IN FEET

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NOTES:

INSIDE THE PLAN AREA POLYCONIC PROJECTION 1927 NORTH AMERICAN DATUM IS SHOWN BY SOLID TICKS AND LAMBERT CONFORMAL CONIC PROJECTION IS SHOWN BY DASHED TICKS

PREPARED FROM AERIAL PHOTOS FLOWN JANUARY 1978

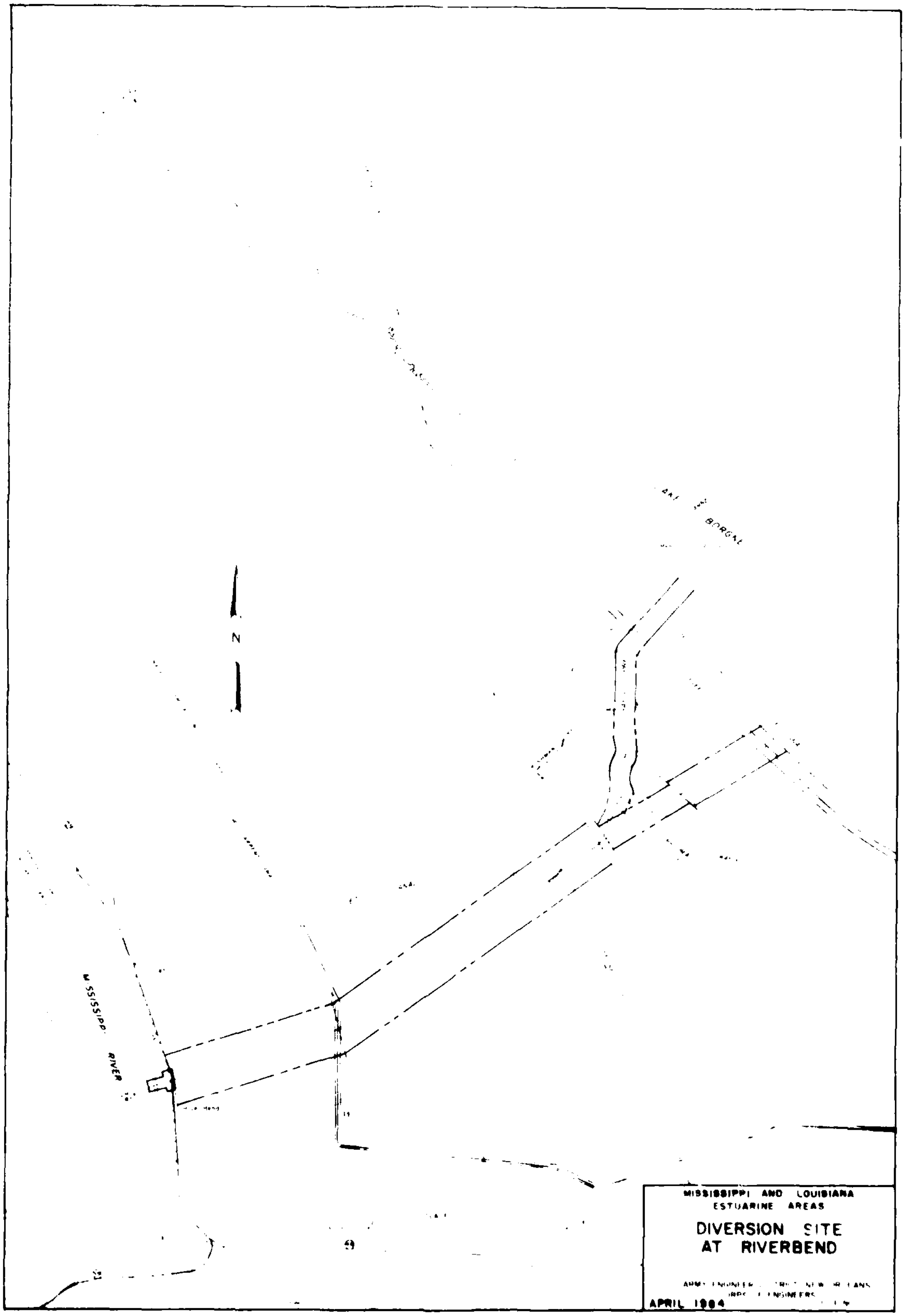

N
MISSISSIPPI RIVER
MISSISSIPPI AND LOUISIANA
ESTUARINE AREAS
DIVERSION SITE
AT RIVERBEND
APRIL 1984

PLATE B-6

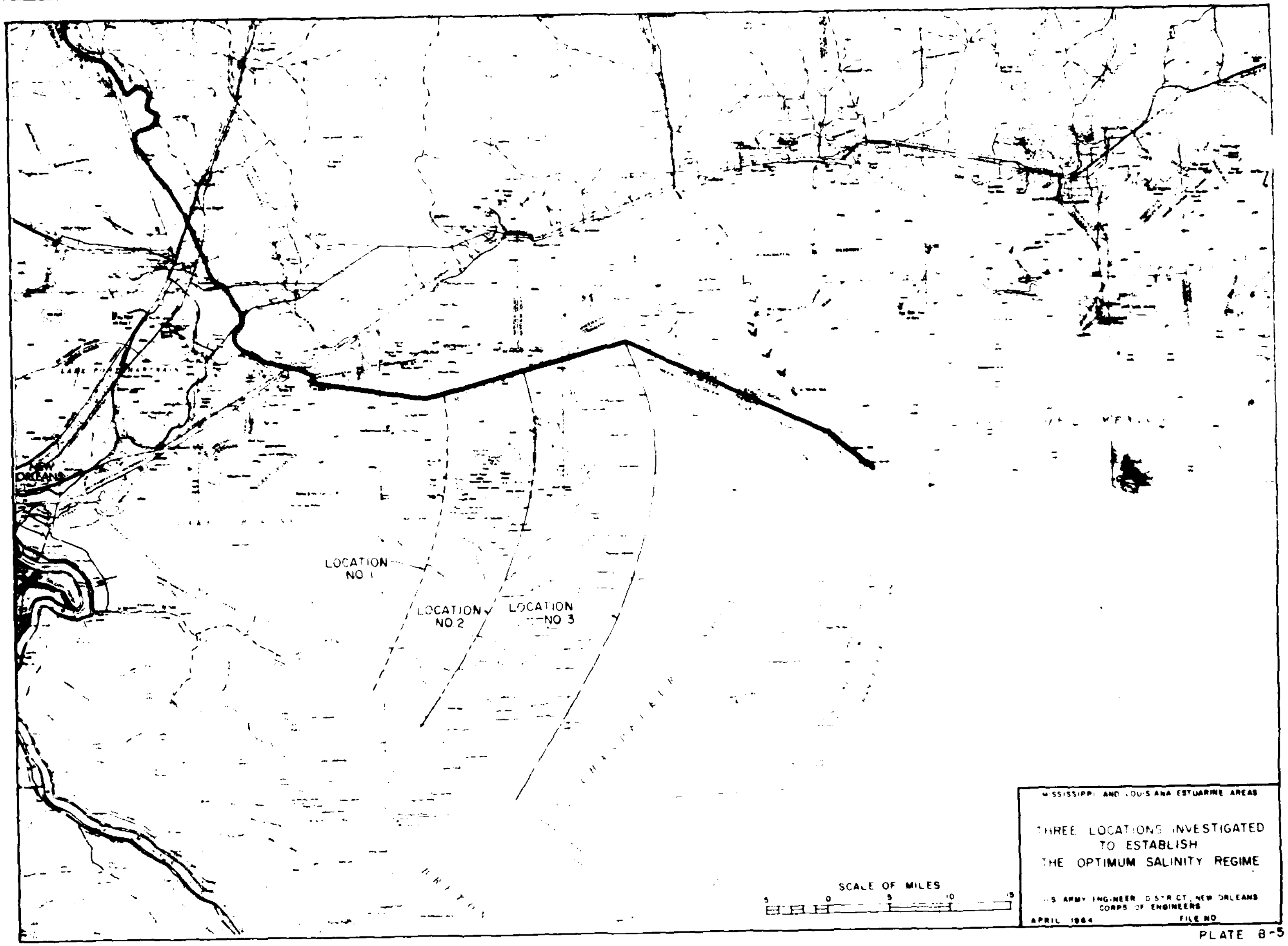
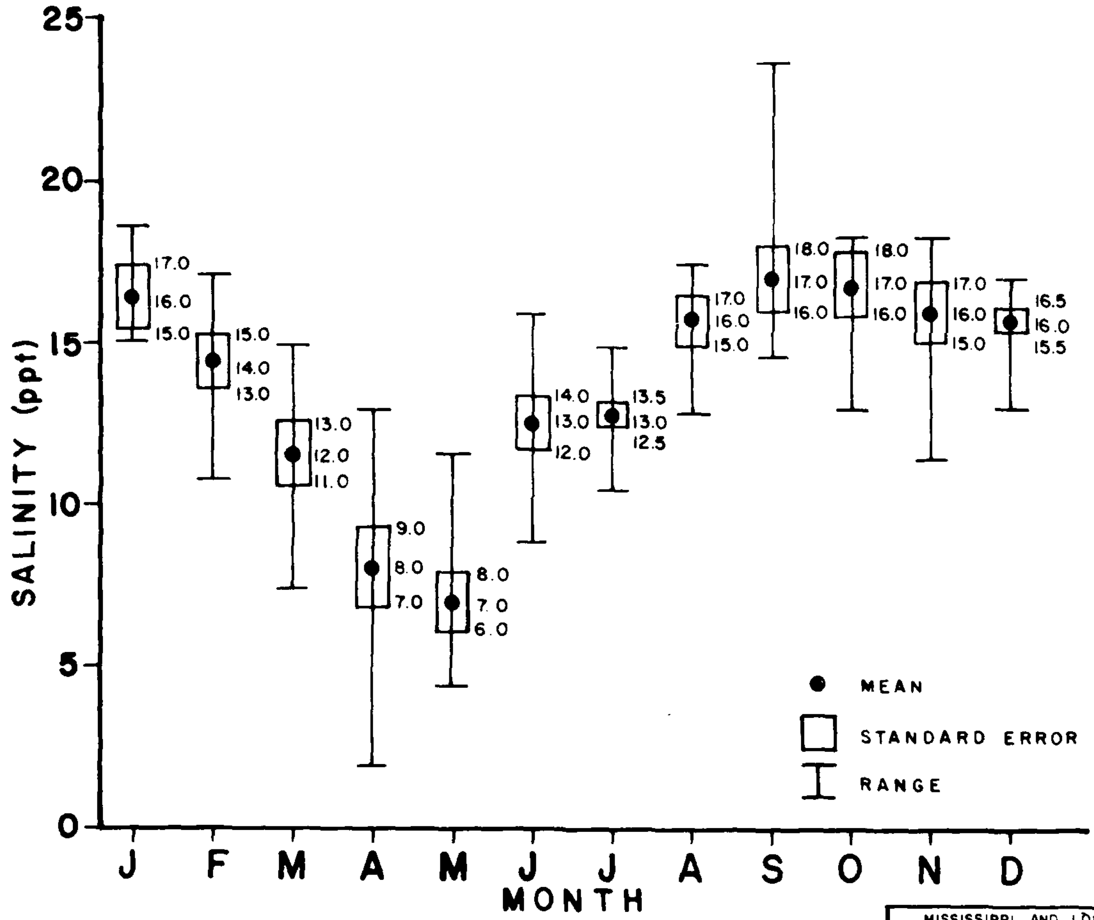

NEW ORLEANS
LOCATION NO 1
LOCATION NO 2
LOCATION NO 3
SCALE OF MILES
5 0 5 10 15
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS
THREE LOCATIONS INVESTIGATED TO ESTABLISH THE OPTIMUM SALINITY REGIME
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
APRIL 1984
FILE NO.

PLATE B-5



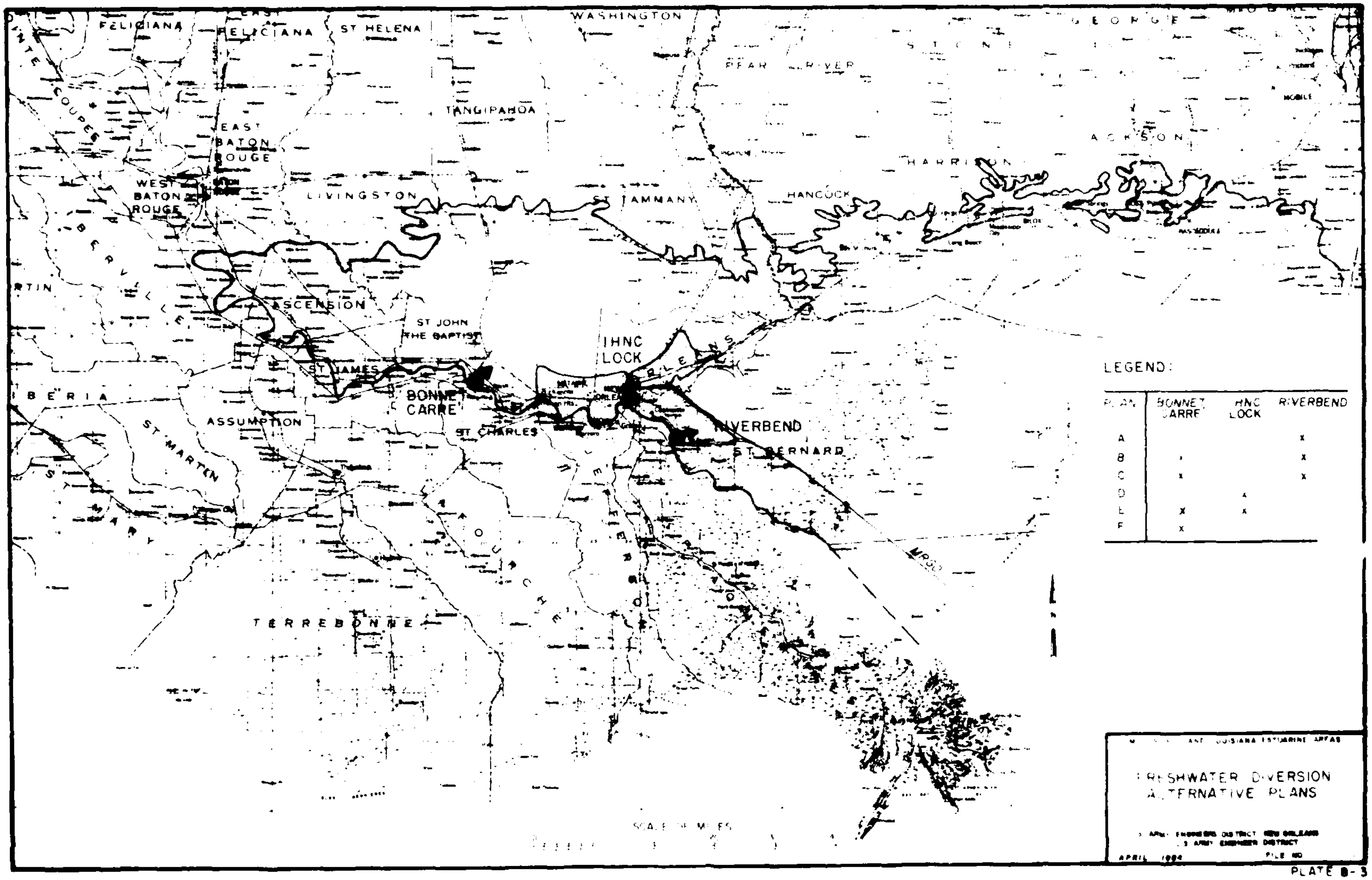
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

OPTIMUM SALINITY REGIME

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

PLATE B-4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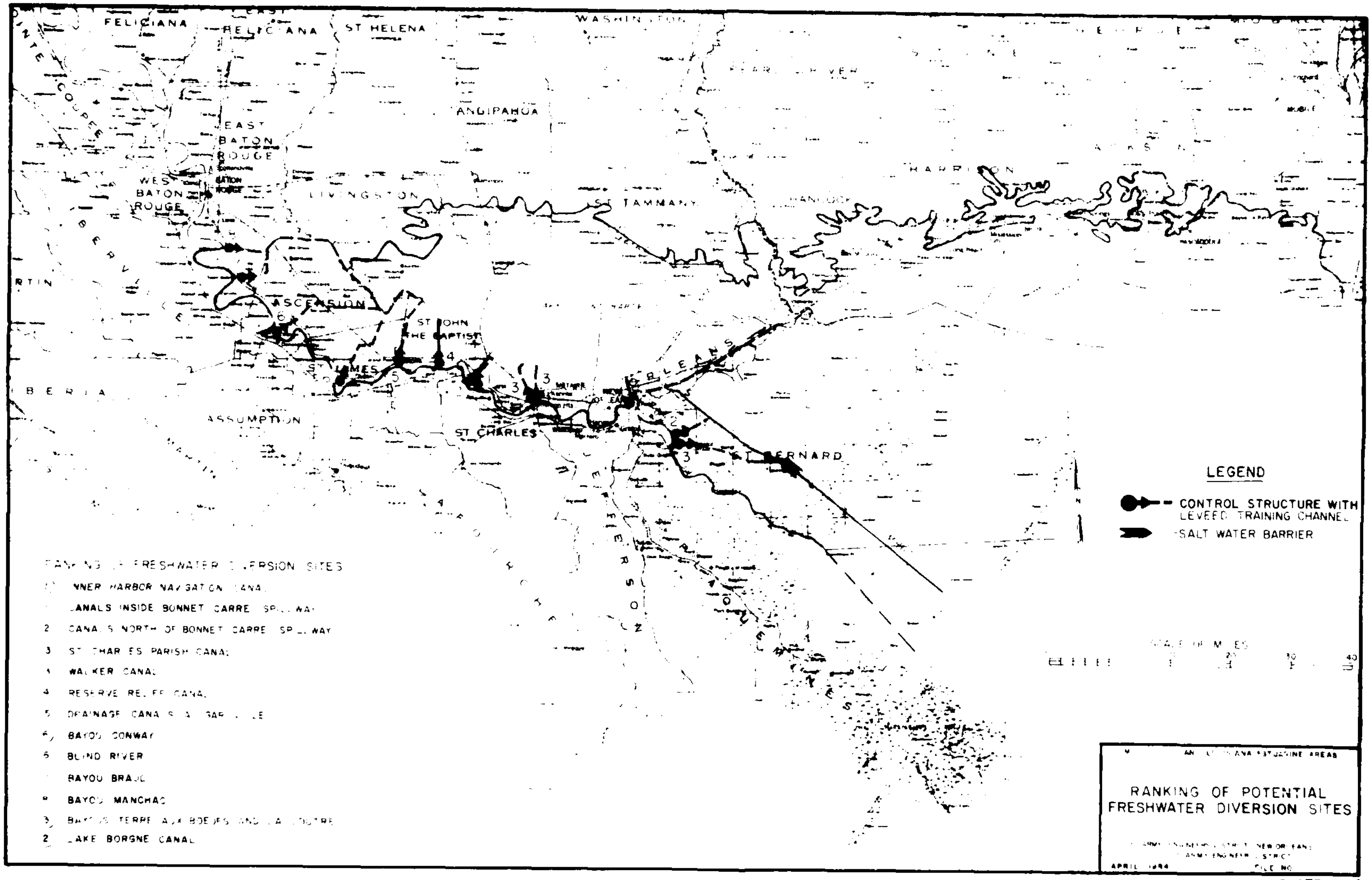
ST HELENA
WASHINGTON
PEAR RIVER
TANGIPAHOA
EAST BATON ROUGE
WEST BATON ROUGE
LIVINGSTON
ST TAMMANY
HANCOCK
HARRISON
ASCENSION
ST JOHN THE BAPTIST
IHNC LOCK
ST JAMES
BONNET CARRE
ASSUMPTION
ST CHARLES
RIVERBEND
ST BERNARD
ST MARTIN
TERREBONNE
LEGEND:
PLAN
BONNET CARRE
IHNC LOCK
RIVERBEND
A
B
C
D
E
F
FRESHWATER DIVERSION
ALTERNATIVE PLANS
APRIL 1984
PLATE B-3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EAST FELICIANA
ST HELENA
WASHINGTON
PEARL RIVER
TANGIPAHOA
EAST BATON ROUGE
WEST BATON ROUGE
LIVINGSTON
ST TAMMANY
HANCOCK
HARRISON
ASCENSION
ST JOHN THE BAPTIST
ST JAMES
ST CHARLES
ORLEANS
ST BERNARD
ASSUMPTION
JEFFERSON
PLAQUEMINES
LEGEND
CONTROL STRUCTURE WITH LEVEED TRAINING CHANNEL
SALT WATER BARRIER
CANALS INSIDE BONNET CARRE SPILLWAY
2 CANALS NORTH OF BONNET CARRE SPILLWAY
3 ST CHARLES PARISH CANAL
WALKER CANAL
4 RESERVE RELIEF CANAL
BAYOU CONWAY
BLIND RIVER
BAYOU BRAUD
BAYOU MANCHAC
2 LAKE BORGNE CANAL
RANKING OF POTENTIAL FRESHWATER DIVERSION SITES
APRIL 1984

PLATE B-2

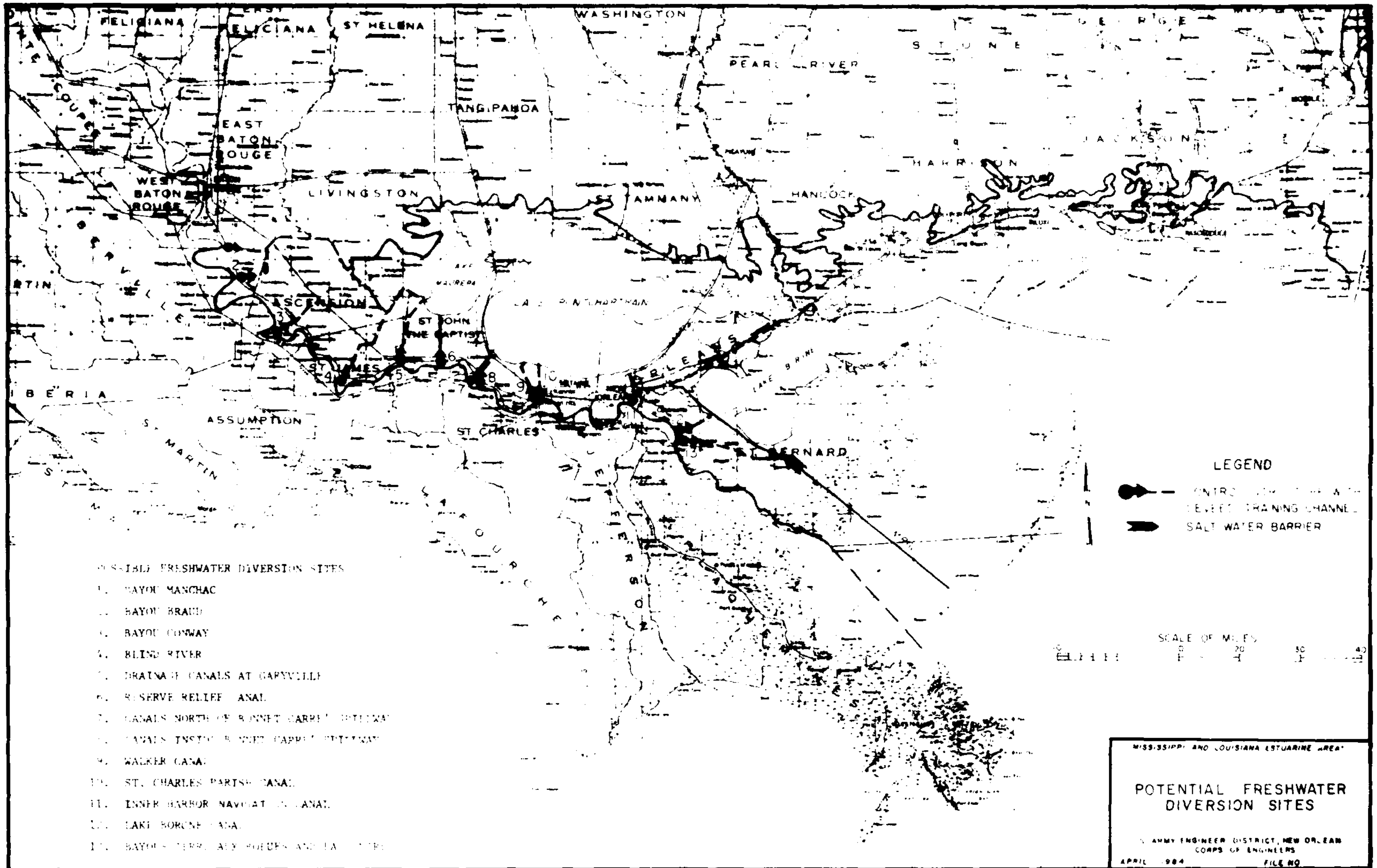
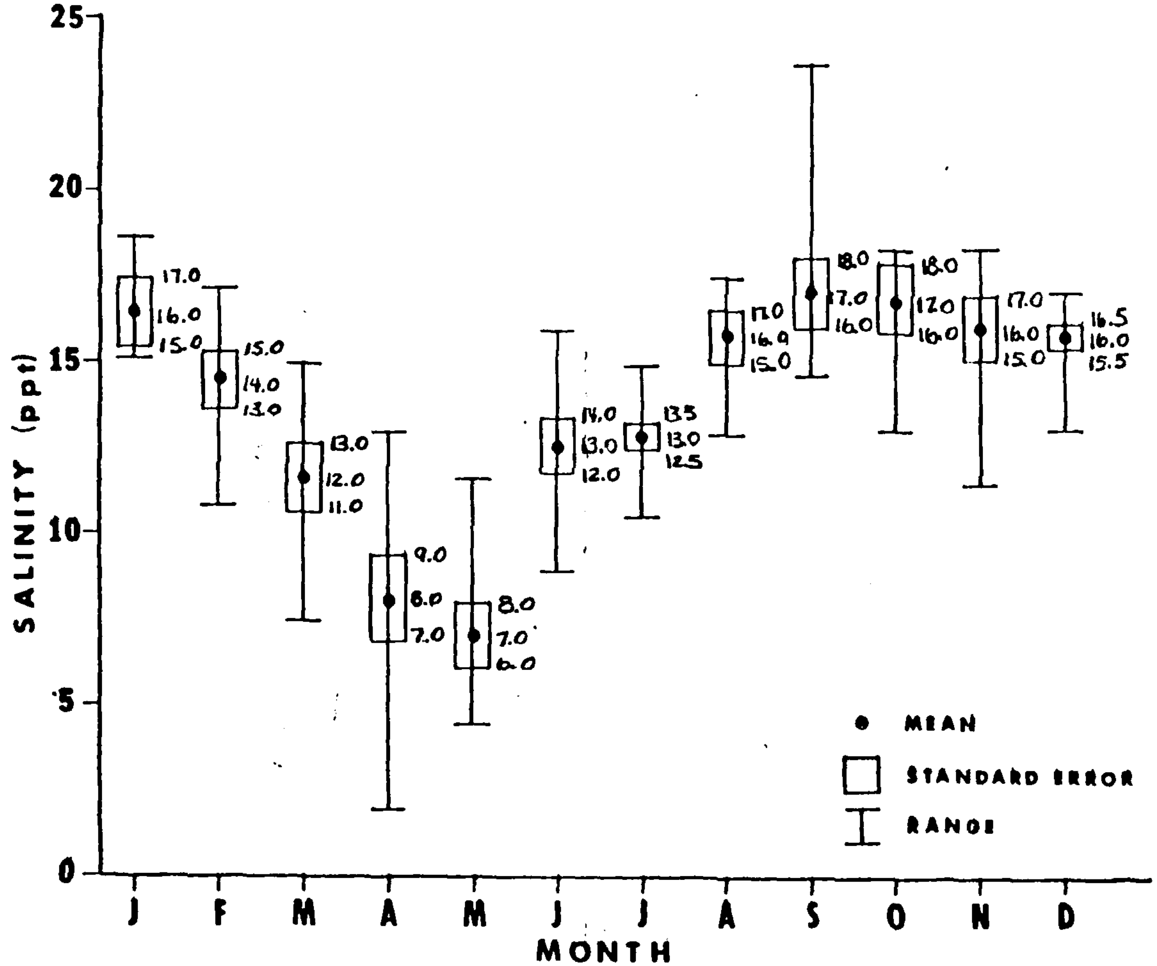

LEGEND
SALT WATER BARRIER
SCALE OF MILES
POSSIBLE FRESHWATER DIVERSION SITES
1. BAYOU MANCHAC
2. BAYOU BRAUD
3. BAYOU CONWAY
4. BLIND RIVER
5. DRAINAGE CANALS AT GARYVILLE
6. RESERVE RELIEF CANAL
7. CANALS NORTH OF BONNET CARRE SPILLWAY
9. WALKER CANAL
10. ST. CHARLES PARISH CANAL
11. INNER HARBOR NAVIGATION CANAL
12. LAKE BORGNE CANAL
MISSISSIPPI AND LOUISIANA ESTUARINE AREA
POTENTIAL FRESHWATER DIVERSION SITES
ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
APRIL 1984
FILE NO
WASHINGTON
ST HELENA
TANGIPAHOA
EAST BATON ROUGE
WEST BATON ROUGE
LIVINGSTON
ASCENSION
ST JOHN THE BAPTIST
ST CHARLES
ASSUMPTION
ST BERNARD
PEARL RIVER
HANCOCK
HARRISON
JACKSON

PLATE B-1


25
20
15
10
5
0
SALINITY (ppt)
17.0
16.0
15.0
15.0
14.0
13.0
13.0
12.0
11.0
9.0
8.0
7.0
8.0
7.0
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14.0
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17.0
16.0
15.0
16.5
16.0
15.5
MEAN
STANDARD ERROR
RANGE
J F M A M J J A S O N D
MONTH

The Ad Hoc Interagency Group concurs with the conclusions and recommendations of the subcommittee.

David Fruge
US Fish and Wildlife Service

Gerald Bodin
US Fish and Wildlife Service

Chuck Killebrew
Louisiana Department of Wildlife and Fisheries

Mark Chatry
Louisiana Department of Wildlife and Fisheries

Ted Ford
Louisiana Department of Wildlife and Fisheries

Barney Barrett
Louisiana Department of Wildlife and Fisheries

Donald Moore
National Marine Fisheries Service

David Chambers
Coastal Management/DNR

J. R. Herring
Mississippi Department of Wildlife Conservation, Bureau of Marine Resources

Fred Deegen
Mississippi Department of Wildlife Conservation, Bureau of Marine Resources

Walter Morse
Louisiana Department of Health and Human Resources

Dennis Chew
US Army Corps of Engineers

Falcolm Hull
US Army Corps of Engineers

John C. Weber
US Army Corps of Engineers

Robert A. Buisson, Jr.
US Army Corps of Engineers

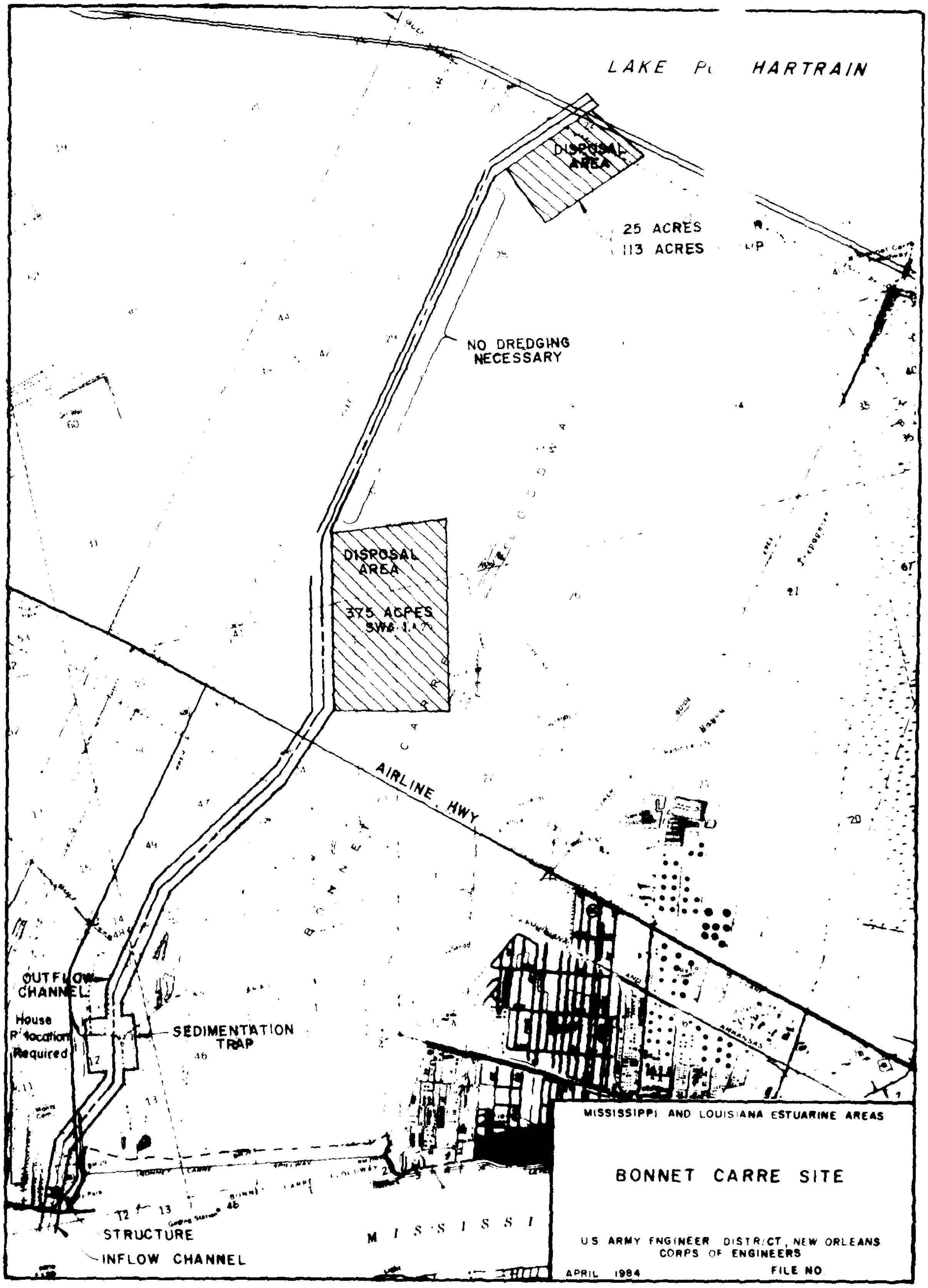
LAKE
HARTRAIN
DISPOSAL AREA
25 ACRES
113 ACRES
NO DREDGING NECESSARY
DISPOSAL AREA
375 ACRES
AIRLINE HWY
OUTFLOW CHANNEL
House Relocation Required
SEDIMENTATION TRAP
STRUCTURE
INFLOW CHANNEL
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS
BONNET CARRE SITE
US ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
APRIL 1984
FILE NO

PLATE B- 9

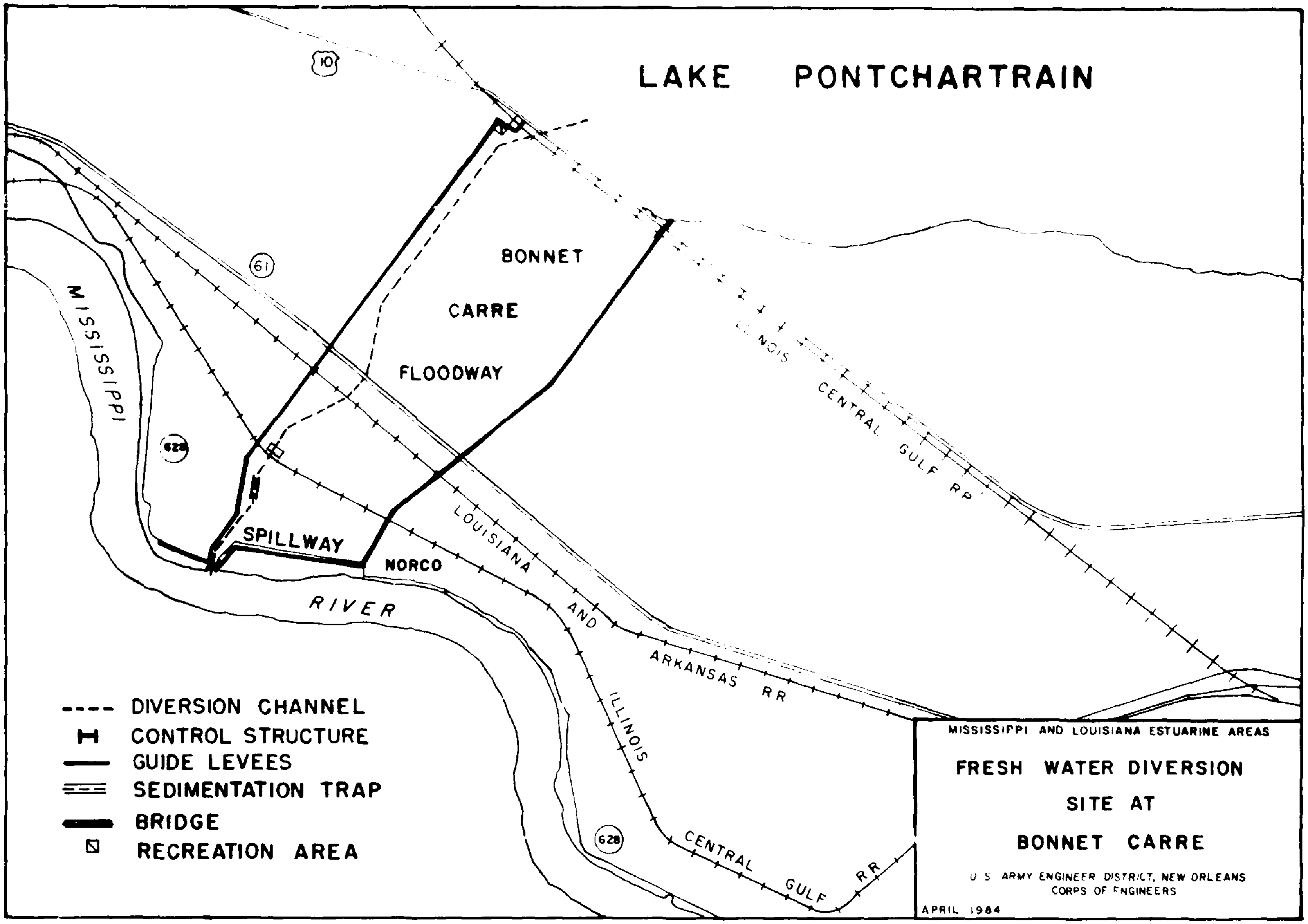
LAKE PONTCHARTRAIN
10
61
628
BONNET
CARRE
FLOODWAY
SPILLWAY
NORCO
MISSISSIPPI
RIVER
ILLINOIS CENTRAL GULF RR
LOUISIANA AND ARKANSAS RR
ILLINOIS CENTRAL GULF RR
DIVERSION CHANNEL
CONTROL STRUCTURE
GUIDE LEVEES
SEDIMENTATION TRAP
BRIDGE
RECREATION AREA
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS
FRESH WATER DIVERSION
SITE AT
BONNET CARRE
U S ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
APRIL 1984

PLATE B-10

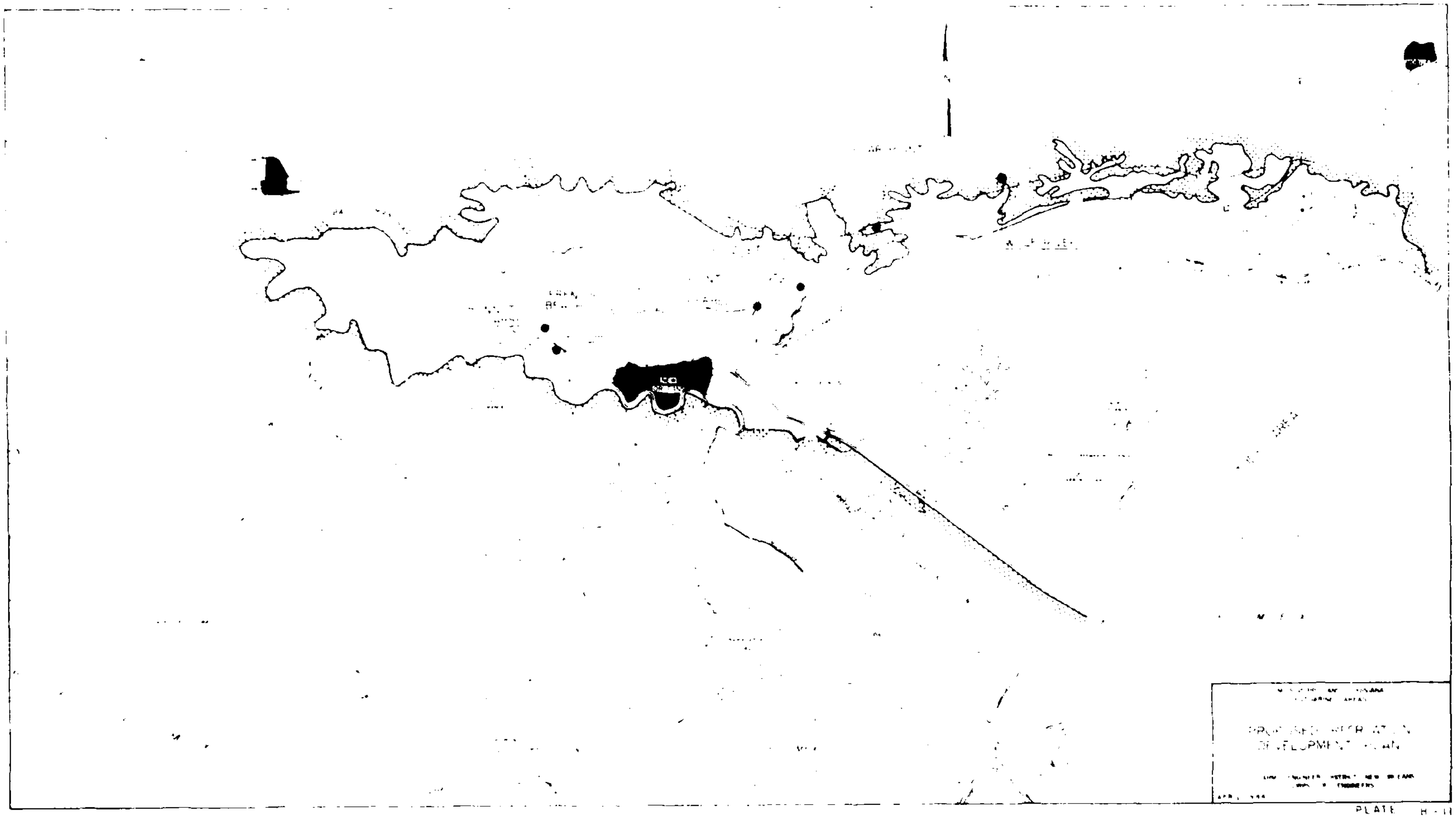

PLATE H-11

APPENDIX C

ENGINEERING INVESTIGATIONS APPENDIX

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF PLATES

LIST OF PLATES (CONTINUED)

MISSISSIPPI AND LOUISIANA ESTUARINE AREAS STUDY

Report on Freshwater Diversion

to the

Lake Pontchartrain Basin and Mississippi Sound

Appendix C

ENGINEERING INVESTIGATIONS

C.0.1. Engineering investigations were conducted to determine hydraulic and hydrologic conditions in the study area and historical changes in salinity. Based on the existing and historical conditions, future salinity changes were projected. From the projected changes, supplemental freshwater quantities required to obtain desirable salinity conditions were determined. Studies were then conducted to identify possible diversion sites, the hydraulic characteristics of diversion structures and channels, and the geology and soils conditions at the sites. Finally, detailed designs and cost estimates were prepared.

Section 1. HYDRAULIC AND HYDROLOGY SURVEY

GENERAL

C.1.1. The hydraulic and hydrologic studies are based on office studies and a review of available information. Climatological and hydrological data were analyzed to document existing conditions and historical salinity changes. To predict future salinity changes, prior studies conducted by Gagliano et al. (1970 a and b, and 1973), Coastal Environment, Inc. (1982), and the US Army Corps of Engineers (1970) were reviewed and their methodologies refined. In the analysis, salinities were correlated with the availability of fresh water. This relationship was used to estimate the supplemental flows required to establish optimal salinity conditions. The optimum locations for introducing supplemental flows were determined through a hydraulic analysis of 13 potential diversion sites. Based on preliminary engineering, environmental, and institutional studies, three sites were selected for detailed hydraulic studies.

CLIMATOLOGY

C.1.2. The climate of the area is humid, sub-tropical, and strongly influenced by the Gulf of Mexico. Throughout the year, warm, moist air from the gulf modifies the relative humidity and temperature conditions over the marshes, and decreases the range between hot and cold temperature extremes. When southerly winds prevail, these maritime effects are increased. Frequently, extended periods of stable humidity and temperature occur. During winter, the climate alternates between cold continental air and tropical air. Prevailing winds in summer transport warm, moist air northward providing favorable conditions for thunderstorms. Summer is also the principal season for occasional tropical storms or hurricanes.

TEMPERATURE

C.1.3. Temperatures in the study area are influenced by warm gulf waters. Table C-1-1 gives the mean water temperatures in the South Louisiana/Mississippi Coast Region for each quarter month. These temperatures are the average temperatures of several sampling sites in the study area. Regional temperature normals are presented in table C-1-2 for the east-central and southeast climatological divisions of Louisiana and for the coastal Mississippi climatological division. Data from the southeast and coastal Mississippi climatological division are pertinent to the study. The other division is listed for comparison. Comparing data in table C-1-1 with air temperature normals in table C-1-2 shows surface waters are usually warmer than the overlying air, on the average. The January high temperature of 71°F in the open gulf results from the surface air which comes over the Gulf of Mexico as a consequence of return flow around the western margins of a high pressure ridge. Monthly air temperatures range from 51°F in January to 81°F in July and August. Average annual temperature is about 68°F.

C.1.4. Extreme changes in the study area air temperatures occur when continental hot or cold air masses penetrate the area. Low temperatures are associated with high pressure systems. These cold air masses are quickly tempered by the gulf climate. This action is apparent when air temperatures over land are compared with air temperatures offshore. Freezing temperatures have been recorded in New Orleans from November through April, and at Baton Rouge, just north of the upper study limits, from October to March (tables C-1-3 and C-1-4, respectively). In the offshore area, freezing temperatures have been recorded only for January and February (Stone, 1972). High temperatures are associated with hot continental air that invades the area, usually in July and August. Normal land air temperatures vary less than 1 degree Fahrenheit in the eastern and western portions of the area throughout most of the year. In December, January, and February, however, this difference increases slightly to 1.5 degrees.

TABLE C-1-11

STATION [illegible] TANGIPAHOA RIVER AT ROBERT, LA.

DISCHARGE (CFS)

[illegible] MONTHLY [illegible] ([illegible] DAYS)

YEAR	OCT	NOV	DEC	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT
1939	323.[illegible]	325.[illegible]	[illegible]	[illegible]	1165.[illegible]	1149.[illegible]	[illegible]	674.[illegible]	1426.0	571.[illegible]	[illegible]	331.00
1940	294.[illegible]	[illegible]	315.[illegible]	341.[illegible]	1651.[illegible]	747.00	1776.[illegible]	1175.[illegible]	434.00	2461.[illegible]	659.00	411.00
1941	371.[illegible]	[illegible]	276.[illegible]	1312.[illegible]	504.[illegible]	624.00	834.[illegible]	435.[illegible]	513.00	653.[illegible]	413.[illegible]	414.[illegible]
1942	331.[illegible]	362.00	[illegible]	1456.	1360.[illegible]	1074.[illegible]	722.[illegible]	418.00	592.00	544.00	721.00	1279.[illegible]
1943	474.[illegible]	275.00	721.[illegible]	1125.	1722.[illegible]	[illegible]	376.[illegible]	611.00	451.00	455.00	424.[illegible]	1193.[illegible]
1944	415.	41[illegible]	[illegible]	2162.	1360.[illegible]	[illegible]	1332.	1393.[illegible]	593.00	421.00	572.[illegible]	727.00
1945	318.[illegible]	1[illegible]	1137.	1634.	2224.[illegible]	1512.[illegible]	1275.	483.00	772.00	378.00	716.00	415.00
1946	425.	[illegible]	1263.	2142.	1666.	1432.[illegible]	673.[illegible]	1773.0	1325.0	3112.[illegible]	953.[illegible]	1267.0
1947	626.[illegible]	1115.	1547.	3473.	476.[illegible]	2443.	481.[illegible]	951.00	655.00	551.00	541.[illegible]	625.0
1948	56[illegible]	161[illegible]	2644.	1267.	2186.[illegible]	4217.[illegible]	42[illegible]	600.00	466.00	481.00	555.10	1526.[illegible]
1949	434.0	3122.	77[illegible]	1276.	2651.[illegible]	665.	2657.[illegible]	2714.0	1348.0	1611.0	126[illegible]	1012.0
1950	721.0	567.0	714.00	1461.[illegible]	2640.0	2466.[illegible]	1056.0	465.00	1703.0	426.00	596.00	555.00
1951	634.00	45[illegible]	443.00	1126.	1602.0	336.[illegible]	2023.	624.00	632.00	650.00	476.[illegible]	422.00
1952	376.[illegible]	[illegible]	664.00	446.[illegible]	1295.0	758.00	1042.[illegible]	678.00	425.00	421.00	373.00	359.00
1953	414.0	[illegible]	565.00	2123.	2734.[illegible]	1559.[illegible]	951.00	4683.[illegible]	876.00	1114.0	473.00	475.00
1954	365.00	56[illegible]	3641.0	1262.[illegible]	751.00	717.00	483.00	630.00	451.00	494.00	367.00	597.00
1955	533.00	4[illegible]	664.00	1444.[illegible]	2236.0	551.00	2234.0	653.00	375.00	565.00	1117.[illegible]	422.00
1956	371.00	46[illegible]	764.[illegible]	534.00	3194.0	2211.[illegible]	653.00	537.00	753.00	752.00	467.00	439.00
1957	394.00	364.00	657.[illegible]	487.00	819.00	931.00	1994.[illegible]	539.00	561.00	450.00	422.00	1381.0
1958	682.00	234[illegible]	1273.0	1134.[illegible]	1481.0	2359.[illegible]	1256.0	1315.0	768.00	450.00	645.00	587.00
1959	452.00	4[illegible]	4[illegible]	636.00	2507.0	450.00	1003.0	1038.0	2615.0	436.00	348.00	542.00
1960	759.00	475.00	1352.0	1184.	1715.0	976.00	1254.0	665.00	421.00	441.00	334.00	502.00
1961	345.00	34[illegible]	413.00	1624.[illegible]	5402.0	3704.0	1411.0	647.00	1025.0	1314.0	494.00	1179.0
1962	362.00	[illegible]	434.	3394.[illegible]	1134.0	41[illegible]	2337.0	1172.[illegible]	1416.0	620.00	55[illegible]	486.[illegible]
1963	553.00	423.00	421.00	667.0	1009.0	695.00	437.00	362.00	356.00	464.00	374.00	356.00
1964	396.00	35[illegible]	567.00	1321.[illegible]	1311.[illegible]	3789.[illegible]	2219.0	774.00	474.00	554.00	602.00	372.00
1965	1594.0	74[illegible]	1662.[illegible]	469.00	2237.0	1454.0	524.00	422.00	376.00	391.00	431.00	452.00
1966	354.00	437.00	[illegible]	2674.[illegible]	7611.0	1917.0	1093.0	812.00	475.00	448.00	488.00	469.00
1967	417.00	432.00	412.00	663.00	947.0	539.00	3292.0	923.00	481.00	415.00	377.00	389.00
1968	27[illegible].00	363.00	774.00	844.00	487.00	667.00	485.00	976.00	494.00	363.00	345.00	321.00
1969	247.00	416.[illegible]	1404.0	675.00	1033.0	1458.0	2145.0	1257.0	447.00	603.00	493.00	373.00
1970	425.00	3[illegible].00	4[illegible]	541.00	564.00	1364.0	701.00	435.00	543.00	539.00	607.00	407.00
1971	1135.0	46[illegible].00	941.00	1233.[illegible]	1151.[illegible]	1382.[illegible]	563.00	1114.[illegible]	524.00	867.00	597.00	3021.0
1972	465.00	335.0	3026.0	1791.[illegible]	1667.[illegible]	1326.[illegible]	622.00	3343.0	430.00	451.00	396.00	361.00
1973	393.00	47[illegible].0	2177.0	1603.	1357.[illegible]	3793.0	4445.[illegible]	1629.[illegible]	643.00	541.00	534.00	1324.0
1974	703.00	1331.	2418.0	3330.	2507.[illegible]	1689.[illegible]	2274.0	3148.0	630.00	561.00	604.00	633.00
1975	464.00	627.0	1165.0	3324.[illegible]	1104.0	2096.[illegible]	1981.0	2434.[illegible]	2746.0	1090.0	1748.0	1228.0
1976	344.00	52[illegible]	725.00	1149.[illegible]	953.00	1113.0	707.00	506.00	482.00	555.00	417.00	349.00
1977	374.00	475.0	915.00	1610.[illegible]	1391.0	1435.0	4537.[illegible]	794.00	443.00	513.00	722.00	2494.0
1978	1191.0	2172.[illegible]	2263.0	2245.[illegible]	1621.0	474.00	734.00	1489.[illegible]	665.00	735.00	451.00	697.00
1979	447.00	54[illegible].00	711.[illegible]	2135.[illegible]	4335.[illegible]	1721.[illegible]	4354.0	1244.0	739.00	1627.0	749.00	697.00
1980	504.00	716.00	991.00	1750.[illegible]	1343.	4353.[illegible]	5437.0	3274.[illegible]	743.00	676.00	575.00	530.00
1981	672.00	731.00	744.00	574.00	1937.	655.00	763.00	690.00	549.00	966.00	477.00	567.00
1982	427.00	434.00	50[illegible].00	1337.	1277.[illegible]	474.00	*	794.00	507.00	548.00	*	471.00
1983	*	*	*	*	*	*	*	*	*	*	*	*

* INDICATES A NO-VALUE MONTH

TABLE C-1-10

STATION 07378500 AMITE RIVER NEAR DENHAM SPRINGS, LA.

DISCHARGE-(CFS)

NORMAL MONTHLY MEANS (ALL DAYS)

YEAR	OCT	NOV	DEC	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT
1938	*	*	*	*	*	*	*	*	*	*	*	412.00
1939	318.00	356.00	500.00	1103.0	2237.0	2679.0	1390.0	2333.0	2587.0	689.00	576.00	483.00
1940	349.00	323.00	441.00	552.00	2582.0	1170.0	3574.0	2146.0	2064.0	5309.0	2909.0	860.00
1941	394.00	1111.0	6040.0	1993.0	972.00	2123.0	1240.0	780.00	1237.0	1026.0	1154.0	525.00
1942	411.00	484.00	1220.0	2066.0	2547.0	3027.0	2771.0	1171.0	1312.0	1100.0	1700.0	235[illegible].0
1943	725.00	615.00	2536.0	2010.0	4133.0	8890.0	1887.0	731.00	683.00	692.00	520.00	1750.0
1944	444.00	1645.0	3027.0	3617.0	2465.0	3700.0	2755.0	1713.0	786.00	522.00	1123.0	922.00
1945	760.00	1383.0	1903.0	3796.0	4736.0	1339.0	2857.0	1808.0	939.00	866.00	775.00	525.00
1946	1136.0	563.00	1971.0	4874.0	3611.0	3674.0	743.00	4294.0	2718.0	3924.0	1301.0	1234.0
1947	593.00	2142.0	1932.0	6982.0	1305.0	6731.0	5366.0	1091.0	1475.0	639.00	591.00	838.00
1948	524.00	2084.0	3924.0	2859.0	4539.0	8997.0	1635.0	1011.0	579.00	582.00	523.00	701.00
1949	467.00	4329.0	6002.0	3078.0	5994.0	6302.0	5538.0	3670.0	1221.0	2792.0	1436.0	987.00
1950	1426.0	836.00	711.00	6062.0	4277.0	4405.0	1874.0	1430.0	3047.0	958.00	840.00	531.00
1951	874.00	507.00	1666.0	2103.0	4657.0	4614.0	4086.0	837.00	1102.0	954.00	596.00	529.00
1952	425.00	467.00	1210.0	620.00	1918.0	1022.0	2018.0	1595.0	556.00	518.00	496.00	359.00
1953	307.00	383.00	834.00	1877.0	5153.0	4680.0	2299.0	13590.0	1050.0	1457.0	1230.0	515.00
1954	367.00	495.00	4297.0	2358.0	1077.0	948.00	1175.0	1619.0	454.00	581.00	386.00	581.00
1955	563.00	405.00	778.00	2573.0	5760.0	850.00	6708.0	937.00	540.00	1127.0	2182.0	537.00
1956	363.00	512.00	2011.0	650.00	6391.0	4975.0	1107.0	535.00	752.00	670.00	442.00	366.00
1957	310.00	334.00	621.00	515.00	1326.0	2260.0	2725.0	1208.0	1146.0	1642.0	550.00	1153.0
1958	1303.0	4733.0	2088.0	2913.0	2679.0	3683.0	2230.0	1610.0	1645.0	1352.0	830.00	1955.0
1959	638.00	518.00	526.00	941.00	6591.0	1721.0	1869.0	2248.0	3048.0	1391.0	1818.0	649.00
1960	733.00	1069.0	3238.0	2618.0	2943.0	1362.0	1065.0	1153.0	500.00	466.00	1120.0	621.00
1961	429.00	578.00	578.00	4100.0	6651.0	6960.0	3647.0	870.00	871.00	1011.0	878.00	1853.0
1962	539.00	2485.0	7197.0	4985.0	1255.0	869.00	5629.0	1730.0	1489.0	653.00	624.00	573.00
1963	556.00	417.00	519.00	1387.0	1403.0	914.00	512.00	419.00	452.00	595.00	531.00	368.00
1964	296.00	350.00	623.00	2122.0	1744.0	7475.0	3030.0	1425.0	579.00	2729.0	833.00	459.00
1965	5821.0	1263.0	3062.0	1061.0	3444.0	3406.0	770.00	512.00	454.00	564.00	638.00	1348.0
1966	425.00	544.00	1378.0	4548.0	11810.0	3649.0	3486.0	1902.0	765.00	638.00	507.00	450.00
1967	434.00	452.00	420.00	686.00	1689.0	823.00	6823.0	3993.0	833.00	623.00	672.00	470.00
1968	395.00	355.00	1474.0	1551.0	609.00	1321.0	1887.0	1737.0	662.00	545.00	602.00	398.00
1969	354.00	463.00	2534.0	906.00	2757.0	3207.0	4410.0	2050.0	467.00	1023.0	495.00	434.00
1970	1839.0	370.00	890.00	856.00	704.00	2189.0	1450.0	696.00	762.00	667.00	543.00	627.00
1971	1449.0	679.00	1371.0	1642.0	2328.0	3054.0	728.00	1384.0	554.00	865.00	669.00	2478.0
1972	578.00	507.00	8592.0	3421.0	2865.0	2961.0	805.00	4845.0	575.00	505.00	452.00	411.50
1973	515.00	785.00	3852.0	2706.0	3353.0	9131.0	8141.0	3092.0	953.00	753.00	625.00	2889.0
1974	665.00	2765.0	[illegible]	7346.0	5288.0	2166.0	3854.0	2062.0	877.00	816.00	731.00	770.00
1975	584.00	1191.0	2197.0	5968.0	1913.0	2984.0	2810.0	6008.0	4551.0	2193.0	4341.0	3007.0
1976	1608.0	786.00	1038.0	1963.0	2222.0	3228.0	1625.0	990.00	638.00	1015.0	533.00	470.00
1977	421.00	666.00	1598.0	3110.0	2419.0	3530.0	10920.0	895.00	506.00	594.00	2463.0	5637.0
1978	1075.0	3343.0	4590.0	4515.0	2975.0	3817.0	1272.0	2695.0	1094.0	884.00	1553.0	1499.0
1979	727.00	812.00	1097.0	4143.0	10440.0	3728.0	10820.0	1659.0	1026.0	1526.0	960.00	1057.0
1980	656.00	1325.0	1792.0	4859.0	3031.0	8866.0	13150.0	5823.0	1251.0	864.00	692.00	714.00
1981	1014.0	1673.0	1871.0	736.00	2423.0	1451.0	1127.0	1479.0	1143.0	1211.0	682.00	729.00
1982	475.00	433.00	744.00	1599.0	5006.0	1266.0	3222.0	1016.0	472.00	*	1224.0	*
1983	*	*	*	*	*	*	*	*	*	*	*	*

* INDICATES A NO-VALUE MONTH

While the principal season for hurricanes in the North Atlantic region is from June through November, the preponderance of hurricanes occurs in August and September. The month of September accounts for one-half of all occurrences of hurricanes affecting the Mississippi Sound. Historically, tropical cyclones have hit the Mississippi Sound area with a mean occurrence of one every 1.3 years. The Louisiana portion of the study area has had 24 occurrences of tropical storms and hurricanes in 77 years (1901-1977).

FRESH WATER RUNOFF AND STREAMFLOW

C.1.14. Estuarine water bodies in the study area receive fresh water from several major rivers, streams, numerous tidal bayous, and by direct rainfall. Urban stormwater runoff from the New Orleans Metropolitan area is also pumped into Lake Pontchartrain. During years of extreme flooding such as in 1937, 1945, 1950, 1973, 1975, 1979, and 1983 on the Mississippi River, fresh water is diverted through the Bonnet Carre' Spillway to Lake Pontchartrain. The total drainage area for Lake Pontchartrain is 5,553 square miles (sq. mi.) including 632 sq. mi. of Lake surface area. Major rivers that discharge into Lakes Maurepas and/or Pontchartrain include Amite River (1,319 sq. mi.), Tangipahoa River (771 sq. mi.), Tickfaw River (727 sq. mi.), Tchefuncta River (450 sq. mi.), and the Natalbany River (218 sq. mi.). A significant amount of the Pearl River (6,367 sq. mi.) discharge enters Lake Pontchartrain through the Rigolets and Chef Menteur Pass. Additional water from the Mississippi River enters Lake Pontchartrain through the Inner Harbor Navigation Lock. Discharge data from these rivers are shown in tables C-1-10 through C-1-15. Most of the inflow into Lake Pontchartrain comes from its tidal passes. Approximately 75 percent of the headwater flow is from the Amite River. The average annual flow to Lake Pontchartrain from the major rivers and streams is 3,600 cfs. Lake Pontchartrain receives about half of its fresh water input from headwater inflow and about half from the tidal passes. Salt budget calculations indicate

TABLE C-1-9

ADJUSTED CLASS A PAN EVAPORATION[1]

LSU BEN HUR EXPERIMENTAL FARM, 1963-1980

MEASURED IN INCHES

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
1963			4.3	5.6	6.9	5.5	4.8	5.1	3.9	4.1	2.3	1.4	47.8
1964	1.4	2.5	3.3	4.0	6.1	5.5	3.8	4.3	4.4	3.3	2.7	1.7	43.2
1965	1.6	2.2	3.3	4.9	5.0	5.9	5.3	4.5	4.6	4.2	2.8	2.1	46.4
1966	1.4	2.0	3.7	5.1	4.9	6.5	4.3	4.0	3.6	3.3	2.7	1.6	43.2
1967	1.6	1.9	4.0	5.4	5.2	5.4	4.2	4.3	3.8	4.0	2.7	1.4	43.7
1968	1.5	2.4	3.3	4.1	5.2	5.8	5.2	5.5	4.4	4.2	2.1	1.7	45.3
1969	2.1	1.7	2.2	4.0	4.2	5.8	4.1	4.6	4.3	3.4	2.1	1.4	40.4
1970	1.1	2.6	3.2	4.5	5.5	5.8	5.1	4.2	3.6	3.2	2.3	1.9	42.9
1971	1.7	2.8	3.4	4.7	6.2	5.5	5.3	4.7	3.1	3.3	2.6	.9	44.2
1972	1.7	2.5	4.0	5.8	5.7	6.6	4.8	5.4	4.0	3.7	2.2	2.1	48.5
1973	2.5	2.4	3.0	2.9	4.7	3.6	6.2	4.8	4.1	4.0	3.1	2.5	43.8
1974	2.9[E]	3.4	4.1	5.1	5.5	5.8		4.4	4.5	4.2	2.6[E]	1.9	
1975	3.5[E]	2.4	4.0	4.9[E]	4.8	5.4	5.8	5.1[E]	4.5	4.1	2.6	2.4	49.5[E]
1976		3.5	3.9	5.3		6.3	5.7	5.7	4.8	4.1	2.8	2.2	
1977	2.4[E]	3.0	4.6		5.9	6.4	6.8	4.8	4.5	3.9	2.7	2.9	
1978		2.5	3.5	5.4	5.1	5.5	5.6	5.9	4.0	5.0	2.8	2.2	
1979	1.1[E]	2.3	4.1	4.3	5.6	6.1	5.8[E]	5.2	4.7	5.0	3.4	1.8	49.4[E]
1980	1.8	2.3	2.9[E]	4.6	5.3[E]	6.2[E]	6.4	6.6	4.7	3.9	2.2	1.5[E]	48.4[E]
MEAN	1.9	2.5	3.6	4.7	5.3	5.7	5.2	4.9	4.2	3.9	2.6	1.9	45.3

URCE: "Variation in the Response Of the Evaporation Rate To the Active Factors Of Weather and Climate: LSU Ben Hur Experimental Farm, Baton Rouge, Louisiana" a master's thesis by R. H. W. Cunningham.

[1]Raw pan EV data has been adjusted by the use of a 0.76 pan coefficient.

[E]Estimated.

some prevailing northerles. Because of the "northers," the winter has the highest average annual wind speeds (9 m.p.h.) and the greatest frequency of winds in excess of 38 m.p.h. Wind speeds for two stations are presented in tables C-1-3 and C-1-4.

EVAPORATION

C.1.11. There are no stations for recording evaporation in the study area; however, evaporation data are available from the Louisiana State University Ben Hur Experimental Farm, Baton Rouge, Louisiana. This station is adjacent to the upper limits of the study area. Data covering the period from 1963-1980, presented in table C-1-9 shows an adjusted annual evaporation of 45.3 inches. Approximately 70 percent of the evaporation occurs in the spring and summer months. January and December have the lowest evaporation rate, with an average loss of 1.9 inch for each month.

C.1.12. Evaporation is the single biggest water loss to the study area. Annual precipitation for the study area exceeds the average annual evaporation by 15.7 inches. However, evaporation significantly exceeds the precipitation during the months of April through June sometimes contributing to drought conditions during these months. Factors which affect the rate of evaporation include humidity, sky cover, and wind stress.

HYDROLOGY

TROPICAL STORMS AND HURRICANES

C.1.13. Circulations with maximum sustained winds up to 38 m.p.h. are tropical depressions. Tropical cyclones with sustained winds from 38 to 73 m.p.h. are classified as tropical storms. When maximum sustained winds exceed 73 m.p.h., the tropical cyclones are called hurricanes.

TABLE C-1-7

PERCENTAGE OF WIND DIRECTIONS

LOUISIANA OFFSHORE AREA

DIRECTION/MONTHS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	19	13	12	10	10	4	4	4	6	13	18	12
NE	16	20	13	18	16	10	10	11	22	34	23	18
E	21	21	20	32	28	30	28	22	33	28	24	22
SE	17	17	27	19	17	23	18	13	13	7	11	16
S	7	10	12	7	6	6	10	8	5	2	6	8
SW	5	3	3	2	3	4	5	7	2	2	2	3
W	5	6	4	4	4	2	6	3	2	2	3	5
NW	10	10	7	7	5	4	4	5	4	4	7	7

SOURCE: Stone 1972

NOTE: Some total monthly percentages do not equal 100 due to periods of no wind.

TABLE C-1-8

PERCENTAGE OF WIND DIRECTIONS

MISSISSIPPI SOUND

DIRECTION/MONTHS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	12	10	9	6	5	5	5	7	10	13	12	12
NE	20	20	16	13	12	12	12	17	31	28	24	23
E	5	4	4	3	2	3	3	3	13	6	5	5
SE	19	19	25	29	24	17	12	12	15	14	15	21
S	7	5	10	13	15	14	11	10	8	6	6	5
SW	11	14	13	16	20	24	22	18	9	7	10	9
W	2	2	2	2	3	4	7	5	2	2	2	13
NW	8	11	12	10	9	5	12	11	7	10	15	11

SOURCE: Mississippi Sound and Adjacent Areas, Dredged Material Disposal Study (Stage 1) Reconnaissance Report, Appendix A, Resource Inventory, March 1979.

NOTE: Some total monthly percentages do not equal 100 due to periods of no wind.

normal precipitation lasting over several continuous months. In table C-1-6, below normal precipitation is apparent from the winter of 1942 through the spring of 1943, from 1951 through 1953, from 1962 to 1963, and from 1968 through 1970. These data indicate that a drought was apparent 7 years in 30, or nearly 25 percent of the period of record.

WINDS

C.1.8. The general circulation of air over the area is dominated by the western extension of the Bermuda High. The circulation is also influenced by high pressure systems over the North American continent. The Bermuda High has greater constancy than the continental high pressure systems and controls the spring and summer climate to a large degree. By late autumn, the continental high pressure system penetrates the area. These systems produce winds with a prevailing direction from the east-northeast (tables C-1-7 and C-1-8).

C.1.9. In Louisiana, winds from the northeast predominate over winds from the southeast during September through February. From March through August, southeast winds predominate. The prevailing winds in southern Mississippi are southerly for March through July, easterly for August and September, and northerly for the remaining months. The relatively constant winds from the east and south travel a great distance over the gulf and carry warm, moist air that fuels the cumuliform cloud development so common to summer.

C.1.10. In the study area, the lowest average wind speeds occur during the summer (6 m.p.h.). This period is occasionally interrupted by tropical storms that produce winds of extremely high velocities. Autumn is the transition from a tropical wind regime to a modified continental wind regime with an average velocity of 8 m.p.h. In winter, the cold high pressure systems from the north penetrate the gulf area and bring

TABLE C-1-6

MONTHLY PALMER DROUGHT INDEX

Southeastern Louisiana Climatic Division

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG ANN
1941	-0.15	-0.18	-0.17	-0.86	-1.01	0.60	0.82	-0.49	-0.43	-0.25	-0.41	-0.37	-0.24
1942	-0.84	1.43	1.65	0.93	0.95	2.34	2.32	2.78	2.75	3.19	-0.47	-0.37	1.38
1943	-0.69	-1.29	-0.65	-1.34	-1.54	-1.48	-1.58	-2.09	1.68	1.13	0.89	0.78	-0.52
1944	2.14	1.72	1.40	2.10	0.03	-0.43	-0.95	-0.86	-0.97	-1.33	1.29	-0.48	0.31
1945	-0.22	-0.18	-0.92	-1.24	-1.37	-1.65	0.95	1.39	1.35	1.29	0.74	1.51	0.14
1946	1.74	1.33	2.58	1.77	3.01	3.91	3.80	2.90	3.65	2.70	2.39	1.78	2.63
1947	2.73	2.33	2.66	2.99	0.02	-0.13	-1.22	-1.45	-1.87	-2.22	1.70	2.53	0.67
1948	2.66	1.62	3.18	-0.75	-1.07	-1.68	-1.78	-1.87	1.63	1.11	2.84	2.57	0.71
1949	1.66	1.13	1.82	2.72	-0.81	-0.88	0.17	0.16	0.59	0.73	-0.61	-0.40	0.52
1950	-1.22	-1.52	0.28	0.94	-0.49	-0.37	-0.04	-0.92	-1.62	-1.79	-2.30	-1.69	-0.89
1951	-1.65	-2.02	-1.49	-0.83	-1.16	-1.62	-1.83	-2.68	-2.42	-2.70	-2.56	-2.93	-1.99
1952	-3.35	-1.91	-2.13	-1.55	-1.20	-1.83	-1.84	-1.97	-2.18	-2.54	-2.71	-2.55	-2.15
1953	-2.83	-2.07	-2.26	-1.65	-2.22	0.39	0.78	1.13	-0.82	-1.37	0.93	2.75	-0.60
1954	0.03	-0.90	-1.45	-2.09	-1.92	-2.05	0.88	-0.89	0.02	0.22	0.01	0.36	-0.65
1955	0.69	-0.24	-1.31	1.10	-1.56	-1.79	0.51	1.29	-0.17	-0.30	-0.16	-0.40	-0.20
1956	-0.45	0.57	-0.44	-0.63	-0.71	1.00	0.95	0.51	1.48	-0.42	-0.82	-0.64	0.03
1957	-1.49	-1.82	0.56	1.08	-0.46	0.50	-0.56	-0.54	1.04	0.95	1.37	0.75	0.12
1958	1.73	1.78	2.08	1.38	1.93	1.78	2.09	2.30	2.47	-0.11	-0.63	-1.35	1.29
1959	-1.34	1.09	0.74	0.60	1.53	2.44	3.48	3.20	2.48	3.53	-0.37	-0.95	1.37
1960	-0.74	-0.34	-0.58	-0.41	-0.45	-1.12	-1.83	0.41	0.18	0.56	-0.76	-0.78	-0.49
1961	0.75	1.31	1.73	1.38	1.36	2.35	2.22	2.56	2.51	2.01	2.53	2.79	1.96
1962	2.65	-1.01	-1.43	-1.81	-2.64	-2.29	-3.18	-353	-3.81	-3.71	-3.68	-3.86	-2.36
1963	-3.52	-2.84	-3.49	-4.25	-4.72	-4.03	-4.01	-4.61	-4.13	-4.52	0.87	1.20	-3.17
1964	2.16	2.77	2.62	-0.01	-0.37	-0.61	0.62	-0.21	-0.75	-0.01	-0.07	-0.70	0.45
1965	0.22	0.65	-0.23	-1.28	-1.71	-1.98	-2.14	0.14	0.72	-0.33	-0.84	0.64	-0.51
1966	2.64	4.11	3.11	3.08	3.80	3.01	3.09	2.97	2.78	2.63	1.92	2.38	2.96
1967	2.24	2.42	-0.65	-1.52	-1.52	-1.59	-1.62	0.78	0.77	1.32	-0.06	1.43	0.17
1968	-0.64	-0.76	-1.09	-1.37	-1.18	-1.36	-1.76	-2.07	-2.56	-2.77	-0.01	0.48	-1.26
1969	0.36	0.30	0.76	0.99	1.47	-0.78	-0.68	-0.66	1.21	-1.76	-2.28	-2.09	-0.47
1970	-1.98	-2.23	-1.46	-2.37	-1.95	-1.95	-2.10	0.37	0.31	1.07	-0.40	-0.82	-1.13

SOURCE: Office of State Climatologist, Louisiana State University, Baton Rouge.

INDEX	CHARACTER OF RECENT WEATHER	INDEX	CHARACTER OF RECENT WEATHER
6.00 to 4.00	Very much wetter than normal	-0.50 to -0.99	Incipient drought
3.99 to 3.00	Much wetter than normal	-1.00 to -1.99	Mild drought
2.99 to 2.00	Moderately wetter than normal	-2.00 to -2.99	Moderate drought
1.99 to 1.00	Slightly wetter than normal	-3.00 to -3.99	Severe drought
0.99 to 0.50	Incipient wet spell	-4.00 to -6.00	Exreme drought
0.49 to -0.49	Nearly normal		

TABLE C-1-5

PRECIPITATION NORMALS BY CLIMATOLOGICAL DIVISIONS, 1941-1970

CLIMATIC DIVISIONS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
						INCHES							
East-Central Louisiana	4.80	5.24	5.91	4.95	4.88	4.84	6.44	5.14	4.71	2.82	4.11	5.86	59.72
Southeast Louisiana	4.53	4.80	5.21	4.16	4.48	5.39	7.54	6.30	7.00	2.87	3.79	5.06	61.14
Coastal Mississippi	4.68	4.80	4.45	4.94	4.22	5.21	7.26	6.04	6.42	2.75	3.83	5.46	62.05

SOURCE: National Weather Service; Monthly Averages of Temperatures and Precipitation for State Climatic Divisions 1941-1970; NOAA National Climatic Center; Asheville, N.C.

PRECIPITATION

C.1.5. The average annual rainfall (1941-1970) in the area is approximately 61 inches. The greatest rainfall occurs from June through September with an average of 6.0 inches per month. Afternoon convective showers and thunderstorms of short duration frequently occur during this period. The driest month is October with an average of 2.8 inches. An occasional tropical storm may increase the rainfall amount significantly in the area. The normal rainfall over the land area is displayed in table C-1-5.

C.1.6. Winter rains generally occur when a warm or cold front enters the area. These frontal rains can begin at any time of day. They are generally slow and relatively continuous and last for several days. Thunder and strong winds often accompany the rains. Although the amount of winter rainfall is less than that of summer, the incidence of rainfall is greater in the winter. Rain occurs on one-third of the winter days. Snow is extremely rare and usually melts as it falls. The rainfall pattern of spring is similar to that of winter.

C.1.7. In an area with abundant rainfall such as southeast Louisiana and southern Mississippi droughts are not often considered to be a significant climatic factor. Drought is relative, however, and rainfall that would be abundant in one region may result in disaster in another. The severity of a drought, often categorized using an index, is called the Palmer Drought Index. The index is based on the concept that the precipitation needed for nearly normal functioning of the regional economy depends on the long-term climate as well as antecedent and current meteorological conditions. Monthly values for the Palmer Drought Index for the Southeastern Climatic Division of Louisiana are presented in table C-1-6. Since evaporation is much less variable than precipitation and since the area under consideration is largely undrained marsh, drought is defined in this study as 10 percent below

TABLE C-1-4

CLIMATOLOGICAL DATA SUMMARY FOR BATON ROUGE

Normals, Means, and Extremes

Month	Temperatures °F: Normal: Daily maximum	Daily minimum	Monthly	Extremes: Record highest	Year	Record lowest	Year	Normal Degree days Base 65 °F: Heating	Cooling	Precipitation in inches: Water equivalent: Normal	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Snow, Ice pellets: Maximum monthly	Year	Maximum in 24 hrs.	Year
(a)				29		29					29		29		29		29		29	
J	61.5	40.5	51.0	82	1957	10	1962	451	17	4.40	9.93	1966	1.15	1971	4.08	1975	0.6	1973	0.5	1973
F	64.5	43.2	53.9	85	1962	20	1958	335	24	4.76	14.51	1966	0.70	1962	4.72	1979	1.8	1973	1.8	1973
M	70.6	48.7	59.7	91	1963	26	1960	208	44	5.14	12.73	1973	0.54	1955	6.07	1973	T	1968	T	1968
A	79.0	57.7	68.4	92	1952	37	1975	33	135	5.10	12.64	1967	0.38	1976	12.08	1967	0.0		0.0	
M	85.2	64.3	74.8	98	1953	44	1954	0	304	4.39	10.70	1953	0.63	1963	4.96	1956	0.0		0.0	
J	90.3	70.3	80.3	103	1954	55	1972	0	459	3.77	11.36	1962	0.12	1979	3.96	1962	0.0		0.0	
J	91.2	72.7	82.0	101	1960	58	1967	0	527	6.51	10.98	1963	2.05	1962	4.26	1969	0.0		0.0	
A	91.1	72.1	81.6	102	1962	59	1967	0	515	4.67	13.31	1977	1.42	1951	3.84	1953	0.0		0.0	
S	87.2	67.7	77.5	97	1963	43	1967	0	375	3.79	13.95	1977	0.09	1953	6.31	1973	0.0		0.0	
O	80.4	56.6	68.5	94	1952	32	1957	54	143	2.65	9.46	1964	T	1978	8.38	1964	0.0		0.0	
N	70.3	46.9	58.6	86	1971	21	1976	208	16	3.84	10.35	1977	0.25	1967	4.67	1973	T	1976	T	1976
D	63.7	42.0	52.9	83	1978	11	1962	381	6	5.03	13.23	1953	1.44	1978	4.12	1953	T	1973	T	1973
YR	77.0	56.9	67.4	103	JUN 1954	10	JAN 1962	1670	2565	54.05	14.51	FEB 1966	T	OCT 1978	12.08	APR 1967	1.8	FEB 1973	1.8	FEB 1973

Month	Relative humidity pct.: Hour 00 (Local time)	Hour 06	Hour 12	Hour 18	Wind: Mean speed m.p.h.	Prevailing direction	Fastest mile: Speed m.p.h.	Direction	Year	Pct. of possible sunshine	Mean sky cover, tenths, sunrise to sunset	Mean number of days: Sunrise to sunset: Clear	Partly cloudy	Cloudy	Precipitation .01 inch or more	Snow, Ice pellets 1.0 inch or more	Thunderstorms	Heavy fog, visibility ½ mile or less	Temperatures °F: Max: (b) 90° and above	32° and below	Min: 32° and below	0° and below	Average station pressure mb, Elev. 76 feet m.s.l.
(a)	20	20	20	20	28	12	17	17			28	28	28	28	28	28	28	28	20	20	20	20	7
J	81	85	66	67	9.3	N	35	23	1975		6.9	7	6	18	9	0	2	5	0	*	10	0	1018.[illegible]
F	78	84	58	60	9.6	NE	35	25	1970		6.2	8	6	14	9	*	3	3	0	0	6	0	1017.[illegible]
M	80	85	57	59	9.7	SE	35	13	1964		6.3	8	8	15	9	0	4	3	*	0	1	0	1016.[illegible]
A	83	89	56	59	9.1	SE	35	25	1964		6.1	7	9	14	7	0	5	3	*	0	0	0	1014.3
M	84	90	56	60	8.0	SE	48	17	1967		5.7	8	12	11	8	0	6	3	6	0	0	0	1011.9
J	85	91	58	63	6.8	SE	40	03	1964		5.5	8	14	8	9	0	9	1	19	0	0	0	1013.7
J	87	91	63	70	6.1	[illegible]	35	36	1970		6.4	4	16	11	14	0	15	2	24	0	0	0	1014.1
A	88	92	63	71	5.7	E	37	32	1975		5.9	7	14	10	12	0	12	2	21	0	0	0	1014.5
S	88	91	61	71	6.9	NE	58	06	1965		5.6	9	11	10	9	0	7	3	11	0	0	0	1012.9
O	85	89	53	65	6.8	NE	40	33	1964		4.3	15	8	8	5	0	2	4	2	0	0	0	1016.2
N	85	88	58	68	7.9	N	31	33	1977		5.6	10	8	12	7	0	2	4	0	0	2	0	1017.3
D	82	86	63	68	8.4	SE	30	18	1966		6.3	9	6	16	10	0	2	4	0	*	7	0	1017.9
YR	84	89	59	65	7.9	SE	58	06	SEP 1965		5.9	100	118	147	108	*	69	37	82	*	26	0	1015.3

Means and extremes above are from existing and comparable exposures. Annual extremes have been exceeded at other sites in the locality as follows: Highest temperature 110 in August 1909; lowest temperature 2 in February 1899; maximum monthly precipitation 23.73 in May 1907; minimum monthly precipitation 0.00 in September 1924.

(a) Length of record, years, through the current year unless otherwise noted, based on January data.
(b) 70° and above at Alaskan stations.
* Less than one half.
T Trace.

NORMALS - Based on record for the 1941-1970 period.
DATE OF AN EXTREME - The most recent in cases of multiple occurrence.
PREVAILING WIND DIRECTION - Record through 1963.
WIND DIRECTION - Numerals indicate tens of degrees clockwise from true north. 00 indicates calm.
FASTEST MILE WIND - Speed is fastest observed 1-minute value when the direction is in tens of degrees.

STATION: Baton Rouge, Louisiana
POSITION: 30° 32' N 91° 08' W
ELEVATION: 64 feet NGVD

SOURCE: "Local Climatological Data 1979"
NOAA National Climatic Center
Asheville, NC

TABLE C-1-3

CLIMATOLOGICAL DATA SUMMARY FOR NEW ORLEANS

Normals, Means, and Extremes

Month	Temperatures °F Normal Daily maximum	Daily minimum	Monthly	Extremes Record highest	Year	Record lowest	Year	Normal Degree days Base 65 °F Heating	Cooling	Precipitation in inches Water equivalent Normal	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year
(a)				33		33					33		33		33	
J	62.3	43.5	52.9	83	1957	14	1963	403	28	4.53	13.63	1978	0.54	1966	6.08	1978
F	65.1	46.0	55.6	85	1972	19	1970	299	35	4.82	12.49	1979	1.02	1962	5.60	1961
M	70.4	50.9	60.7	87	1963	26	1968	186	55	5.49	19.09	1948	0.24	1955	7.87	1948
A	78.4	58.8	68.6	91	1948	32	1971	29	137	4.15	10.47	1973	0.28	1976	5.18	1977
M	84.9	65.3	75.1	96	1953	41	1960	0	313	4.20	14.33	1959	0.99	1969	9.86	1959
J	89.6	71.2	80.4	100	1954	55	1972	0	462	4.74	12.28	1975	0.23	1979	4.19	1953
J	90.4	73.1	81.9	99	1951	60	1967	0	524	6.72	11.46	1954	2.91	1977	4.30	1966
A	90.6	73.1	81.9	100	1951	60	1968	0	524	5.27	16.12	1977	1.69	1976	4.82	1975
S	86.6	69.7	78.2	97	1954	42	1967	0	396	5.58	16.74	1971	0.24	1953	6.50	1971
O	79.9	59.6	69.8	92	1977	35	1968	40	189	2.26	6.45	1959	0.00	1978	3.44	1975
N	70.3	49.8	60.1	86	1979	24	1970	179	32	3.88	14.58	1947	0.21	1949	8.72	1975
D	64.2	45.3	54.8	84	1978	17	1962	327	11	5.13	10.77	1967	1.46	1958	4.65	1973
YR	77.7	58.9	68.3	100	JUN 1954	14	JAN 1963	1465	2706	56.77	19.09	MAR 1948	0.00	OCT 1978	9.86	MAY 1959

Month	Snow, Ice pellets Maximum monthly	Year	Maximum in 24 hrs.	Year	Relative humidity pct. Hour 00 (Local time)	Hour 06	Hour 12	Hour 18	Wind Mean speed m.p.h.	Prevailing direction	Fastest mile Speed m.p.h.	Direction	Year
(a)	33		33		31	31	31	31	31		20	20	
J	0.1	1973	0.1	1973	83	85	67	73	9.5		46	21	1975
F	2.0	1958	2.0	1958	82	84	63	67	9.9		43	26	1970
M	T	1959	T	1959	82	85	61	65	10.1		37	18	1969
A	0.0		0.0		85	88	60	66	9.5		35	07	1960
M	0.0		0.0		86	89	60	65	8.2		55	36	1973
J	0.0		0.0		86	89	62	67	6.9		48	05	1971
J	0.0		0.0		89	91	66	73	6.2		44	13	1979
A	0.0		0.0		89	91	66	73	6.0		42	33	1969
S	0.0		0.0		87	89	66	75	7.3		69	09	1965
O	0.0		0.0		84	88	59	72	7.5		40	17	1964
N	T	1950	T	1950	84	86	61	74	8.7		30	31	1969
D	2.7	1963	2.7	1963	83	86	66	75	9.1		46	28	1973
YR	2.7	DEC 1963	2.7	DEC 1963	85	88	63	70	8.3		69	09	SEP 1965

Month	Pct. of possible sunshine	Mean sky cover, tenths, sunrise to sunset	Mean number of days Sunrise to sunset Clear	Partly cloudy	Cloudy	Precipitation .01 inch or more	Snow, Ice pellets 1.0 inch or more	Thunderstorms	Heavy fog, visibility 1/4 mile or less	Temperatures °F Max 90° and above (b)	Max 32° and below	Min 32° and below	Min 0° and below	Average station pressure mb Elev. 30 feet m.s.l.
(a)	6	31	31	31	31	31	31	31	31	33	33	33	33	7
J	46	6.8	7	[illegible]	17	10	0	2	7	0	*	5	0	1019.9
F	59	6.1	8	7	13	9	*	3	4	0	0	7	0	1019.1
M	56	6.3	8	8	15	9	0	4	4	0	0	*	0	1015.7
A	65	5.7	8	11	11	7	0	4	2	*	0	*	0	[illegible]
M	59	5.8	10	12	9	8	0	6	1	3	0		0	[illegible]
J	66	5.1	10	13	7	10	0	9	*	16	0		0	[illegible]
J	56	6.3	5	15	11	15	0	16	*	20	0	0	0	1015.6
A	55	5.6	8	14	9	13	0	13	*	19	0	0	0	1015.8
S	58	5.4	10	10	10	10	0	7	*	8	0	0	0	1016.0
O	71	4.1	16	8	7	5	0	2	2	1	0	0	0	1017.3
N	57	5.1	11	8	11	7	0	2	4	0	0	1	0	1018.7
D	56	6.2	8	8	15	10	*	2	5	0	*	4	0	1019.2
YR	59	5.7	109	121	135	114	*	69	30	69	*	13	0	1016.6

Means and extremes above are from existing and comparable exposures. Annual extremes have been exceeded at other sites in the locality as follows: Highest temperature 102 in June 1954 and earlier (City Office); lowest temperature 7 in February 1899; maximum monthly precipitation 25.11 in October 1937; maximum precipitation in 24 hours 14.01 in April 1927; maximum monthly snowfall 8.2 in February 1895; maximum snowfall in 24 hours 8.2 in February 1895.

(a) Length of record, years, through the current year unless otherwise noted, based on January data.
(b) 70° and above at Alaskan stations.
* Less than one half.
T Trace.

NORMALS - Based on record for the 1941-1970 period.
DATE OF AN EXTREME - The most recent in cases of multiple occurrence.
PREVAILING WIND DIRECTION - Record through 1963.
WIND DIRECTION - Numerals indicate tens of degrees clockwise from true north. 00 indicates calm.
FASTEST MILE WIND - Speed is fastest observed 1-minute value when the direction is in tens of degrees.

STATION: New Orleans, Louisiana
POSITION: 29°59'N 90° 15' W
ELEVATION: 4 feet NGVD

SOURCE: "Local Climatological Data 1979"
NOAA National Climatic Center
Asheville, NC

TABLE C-1-2

TEMPERATURE NORMALS BY CLIMATOLOGICAL DIVISION, 1941-1970

CLIMATIC DIVISIONS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUC	SEP	OCT	NOV	DEC	ANNUAL
						DEGREES FAHRENHEIT							
East-Central Louisiana	51.1	53.9	59.3	67.7	74.0	79.7	81.5	81.2	77.1	68.0	58.3	52.6	67.0
Southeast Louisiana	54.3	56.7	61.5	69.3	75.5	80.7	82.2	82.2	78.9	71.0	61.6	56.2	69.2
Coastal Mississippi	51.5	54.3	53.4	67.9	74.5	80.1	81.5	81.4	77.5	68.8	58.9	53.2	67.4

SOURCE: National Weather Service

TABLE C-1-1

MEAN WATER TEMPERATURES
IN
SOUTH LOUISIANA AREA (°F)

WATER BODY	JAN	APR	JUL	OCT
Mississippi River				
@ New Orleans[a]	44	58	82	72
Open Gulf of Mexico[b]	71	73	85	81
Eastern Marshes[c]	55	72	85	81
Lake Pontchartrain[d]	54	71	86	78
Mississippi Sound[e]	54	69*	85	73

*Maybe 5°F warmer in Bays

[a]U.S. Geological Survey, 1967-1976

[b]U.S. Naval Weather Service Command, 1972

[c]Coastal Resource Unit, 1970

[d]Tarver and Savoie, 1976

[e]Christmas and Eleuterius, 1973

TABLE C-1-12

STATION 07376000 TICKFAW RIVER AT HOLDEN, LA.

DISCHARGE-(CFS)

NORMAL MONTHLY MEANS (ALL DAYS)

YEAR	OCT	NOV	DEC	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT
1941	100.00	204.00	1105.0	386.00	161.00	362.00	309.00	141.00	179.00	169.00	249.00	143.00
1942	103.00	105.00	250.00	408.00	486.00	512.00	241.00	319.00	318.00	264.00	535.00	579.00
1943	154.00	135.00	532.00	397.00	663.00	1696.0	273.00	165.00	166.00	171.00	166.00	314.00
1944	111.00	265.00	356.00	607.00	390.00	612.00	423.00	279.00	198.00	123.00	187.00	184.00
1945	113.00	213.00	309.00	557.00	765.00	250.00	442.00	366.00	147.00	239.00	162.00	111.00
1946	244.00	133.00	349.00	827.00	534.00	855.00	148.00	641.00	413.00	891.00	353.00	417.00
1947	149.00	339.00	421.00	1310.0	265.00	1190.0	1199.0	233.00	218.00	131.00	122.00	183.00
1948	136.00	592.00	991.00	416.00	790.00	1578.0	293.00	192.00	131.00	142.00	131.00	277.00
1949	119.00	790.00	992.00	454.00	960.00	1037.0	947.00	656.00	265.00	468.00	289.00	209.00
1950	229.00	134.00	163.00	831.00	866.00	926.00	375.00	209.00	806.00	207.00	191.00	178.00
1951	155.00	129.00	279.00	448.00	928.00	790.00	684.00	158.00	157.00	170.00	122.00	121.00
1952	95.70	104.00	148.00	127.00	382.00	209.00	358.00	246.00	135.00	119.00	107.00	101.00
1953	81.10	87.50	150.00	349.00	754.00	742.00	372.00	1960.0	185.00	371.00	245.00	132.00
1954	95.10	147.00	1145.0	467.00	219.00	186.00	230.00	296.00	111.00	111.00	88.60	172.00
1955	117.00	110.00	140.00	508.00	903.00	138.00	860.00	183.00	115.00	262.00	840.00	116.00
1956	95.80	110.00	291.00	163.00	1126.0	904.00	207.00	135.00	136.00	114.00	103.00	89.30
1957	87.00	85.80	125.00	98.10	261.00	349.00	435.00	142.00	116.00	116.00	98.70	452.00
1958	183.00	947.00	371.00	385.00	569.00	770.00	389.00	528.00	193.00	287.00	187.00	165.00
1959	110.00	98.90	103.00	142.00	997.00	287.00	280.00	279.00	927.00	272.00	309.00	121.00
1960	248.00	202.00	418.00	464.00	706.00	252.00	281.00	179.00	104.00	102.00	167.00	105.00
1961	100.00	94.20	101.00	417.00	1627.0	1270.0	619.00	177.00	180.00	287.00	277.00	246.00
1962	132.00	501.00	1565.0	1144.0	265.00	218.00	1118.0	498.00	338.00	153.00	143.00	152.00
1963	119.00	111.00	122.00	245.00	304.00	197.00	118.00	97.40	129.00	150.00	120.00	92.80
1964	82.70	95.10	139.00	509.00	427.00	1407.0	738.00	335.00	130.00	163.00	130.00	96.80
1965	591.00	273.00	693.00	241.00	767.00	669.00	162.00	113.00	101.00	112.00	106.00	146.00
1966	102.00	94.20	155.00	681.00	2592.0	798.00	500.00	285.00	124.00	142.00	175.00	108.00
1967	109.00	101.00	117.00	193.00	326.00	146.00	1210.0	410.00	133.00	151.00	156.00	158.00
1968	90.90	99.00	126.00	228.00	115.00	226.00	587.00	276.00	125.00	97.70	85.10	75.00
1969	71.20	74.00	543.00	168.00	387.00	507.00	909.00	302.00	112.00	158.00	113.00	84.30
1970	84.70	76.70	116.00	146.00	156.00	354.00	282.00	107.00	130.00	115.00	110.00	96.30
1971	249.00	112.00	303.00	371.00	389.00	423.00	158.00	159.00	122.00	135.00	99.40	642.00
1972	124.00	96.20	1274.0	569.00	547.00	587.00	162.00	1159.0	137.00	132.00	116.00	98.90
1973	114.00	137.00	612.00	524.00	524.00	1390.0	1776.0	423.00	224.00	151.00	139.00	613.00
1974	150.00	455.00	860.00	1374.0	969.00	504.00	586.00	1299.0	192.00	146.00	152.00	180.00
1975	104.00	171.00	335.00	1211.0	339.00	527.00	668.00	914.00	681.00	266.00	496.00	258.00
1976	230.00	141.00	158.00	251.00	219.00	323.00	193.00	129.00	115.00	182.00	132.00	98.20
1977	94.20	123.00	293.00	590.00	389.00	482.00	1816.0	213.00	113.00	131.00	219.00	1192.0
1978	250.00	957.00	1126.0	934.00	595.00	314.00	245.00	546.00	162.00	155.00	230.00	185.00
1979	103.00	110.00	157.00	703.00	1979.0	651.00	1825.0	337.00	184.00	389.00	143.00	127.00
1980	110.00	222.00	347.00	687.00	436.00	1379.0	2253.0	1133.0	225.00	161.00	143.00	139.00
1981	152.00	189.00	215.00	149.00	501.00	214.00	212.00	174.00	223.00	180.00	112.00	186.00
1982	114.00	105.00	154.00	334.00	821.00	268.00	471.00	*	113.00	128.00	323.00	115.00
1983	*	*	*	*	*	*	*	*	*	*	*	*

* INDICATES A NO-VALUE MONTH

TABLE C-1-13

STATION 07375000 TCHEFUNCTA RIVER NEAR FOLSOM, LA.

DISCHARGE-(CFS)

NORMAL MONTHLY MEANS (ALL DAYS)

YEAR	OCT	NOV	DEC	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT
1944	45.00	114.00	157.00	385.00	173.00	297.00	155.00	189.00	81.60	52.30	96.60	98.20
1945	109.00	249.00	218.00	269.00	257.00	232.00	193.00	121.00	56.70	78.10	112.00	50.30
1946	136.00	63.40	190.00	353.00	286.00	433.00	85.00	245.00	243.00	285.00	121.00	85.80
1947	58.50	93.90	179.00	502.00	101.00	542.00	789.00	174.00	134.00	63.00	85.10	81.70
1948	56.80	293.00	630.00	170.00	279.00	600.00	105.00	84.80	57.40	93.90	91.40	260.00
1949	57.20	790.00	366.00	168.00	294.00	349.00	353.00	405.00	98.60	302.00	325.00	242.00
1950	121.00	75.10	98.90	209.00	409.00	424.00	160.00	109.00	128.00	125.00	70.50	110.00
1951	65.30	58.10	133.00	164.00	395.00	376.00	218.00	64.50	70.80	65.80	52.50	72.30
1952	47.50	53.70	83.20	63.60	220.00	106.00	157.00	74.40	49.20	54.40	51.70	46.00
1953	37.10	41.90	75.50	192.00	291.00	232.00	144.00	853.00	69.10	192.00	146.00	50.20
1954	44.10	87.00	866.00	190.00	97.70	81.90	153.00	60.10	54.20	74.50	51.50	44.60
1955	55.80	53.70	73.90	185.00	209.00	53.60	201.00	65.30	40.30	44.30	71.50	39.20
1956	36.60	48.80	73.90	58.00	537.00	264.00	61.80	48.50	90.20	133.00	49.60	49.40
1957	49.60	44.40	128.00	57.70	100.00	93.20	371.00	49.50	58.80	46.10	53.40	176.00
1958	89.50	401.00	160.00	194.00	220.00	359.00	155.00	229.00	63.00	111.00	84.60	76.80
1959	47.70	52.90	54.10	77.50	424.00	110.00	86.10	126.00	373.00	123.00	144.00	60.90
1960	99.80	99.00	101.00	146.00	249.00	104.00	156.00	74.80	48.00	46.90	144.00	67.10
1961	46.20	49.30	54.80	206.00	1257.0	493.00	194.00	83.10	69.10	161.00	70.50	161.00
1962	53.60	800.00	738.00	500.00	114.00	87.50	302.00	85.40	169.00	65.50	59.80	56.40
1963	106.00	55.40	73.60	106.00	166.00	107.00	50.60	44.80	42.50	72.80	51.50	55.60
1964	38.00	41.70	66.70	169.00	208.00	570.00	314.00	93.90	55.40	71.40	57.50	41.20
1965	80.90	91.50	285.00	187.00	357.00	159.00	62.50	47.40	44.80	49.50	65.80	65.30
1966	40.00	40.00	54.50	296.00	1102.0	262.00	145.00	85.30	71.40	56.10	64.80	49.20
1967	44.40	45.30	51.80	65.40	143.00	59.20	388.00	247.00	63.40	43.80	44.60	39.10
1968	36.70	40.40	101.00	151.00	57.70	87.30	85.30	50.20	35.50	36.80	34.30	31.10
1969	32.00	40.80	209.00	86.70	107.00	244.00	327.00	147.00	42.50	82.80	43.90	36.70
1970	45.00	40.50	51.30	75.50	92.70	178.00	83.40	71.00	66.50	103.00	51.10	38.00
1971	92.10	55.70	135.00	162.00	168.00	163.00	58.10	200.00	50.40	62.20	56.10	347.00
1972	49.40	44.10	553.00	294.00	208.00	205.00	72.60	670.00	58.20	77.20	46.40	44.60
1973	47.40	73.20	346.00	196.00	141.00	621.00	797.00	176.00	68.90	76.40	57.60	156.00
1974	130.00	231.00	560.00	423.00	332.00	359.00	328.00	381.00	100.00	81.70	68.80	71.90
1975	52.50	118.00	127.00	418.00	133.00	251.00	426.00	360.00	346.00	134.00	133.00	105.00
1976	80.80	71.60	79.80	162.00	157.00	154.00	75.40	61.60	58.00	101.00	66.60	51.90
1977	41.40	59.20	164.00	232.00	136.00	201.00	702.00	87.60	52.70	59.80	148.00	419.00
1978	216.00	398.00	311.00	304.00	200.00	144.00	163.00	171.00	68.20	72.30	69.60	69.30
1979	48.60	60.30	76.80	221.00	513.00	223.00	628.00	151.00	70.40	119.00	56.70	90.20
1980	50.70	75.90	194.00	204.00	114.00	610.00	544.00	245.00	87.80	70.30	56.90	55.70
1981	68.30	82.20	70.50	60.20	333.00	91.20	65.10	79.40	76.10	85.60	44.00	77.80
1982	38.10	39.50	58.90	105.00	313.00	74.70	194.00	*	48.90	53.70	111.00	39.10
1983	*	*	*	*	*	*	*	*	*	*	*	*

* INDICATES A NO-VALUE MONTH

TABLE C-1-14

STATION 07376500   NATALBANY RIVER AT BAPTIST, LA.

DISCHARGE-(CFS)

[illegible] MONTHLY MEANS (ALL DAYS)

YEAR	OCT	NOV	DEC	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT
1943	*	*	*	*	*	*	*	*	*	*	*	253.00
1944	7.42	[illegible]	105.00	300.00	130.00	199.00	64.20	128.00	23.60	7.64	22.50	34.60
1945	9.08	137.00	108.00	214.00	257.00	31.90	113.00	79.50	13.30	85.10	45.70	15.00
1946	121.00	7.95	114.00	301.00	165.00	375.00	12.30	257.00	141.00	230.00	74.60	45.40
1947	17.90	75.50	72.80	417.00	21.60	529.00	439.00	29.80	25.60	4.55	7.78	76.90
1948	20.70	317.00	521.00	124.00	180.00	520.00	31.70	17.20	6.05	12.80	4.94	108.00
1949	5.75	751.00	315.00	94.90	247.00	286.00	243.00	121.00	32.70	190.00	120.00	59.10
1950	70.10	3.37	31.30	173.00	322.00	352.00	92.60	29.70	412.00	29.60	25.60	41.00
1951	24.90	9.49	75.10	130.00	240.00	374.00	90.70	16.60	13.60	33.40	15.20	17.30
1952	7.04	5.51	11.40	13.20	181.00	50.80	144.00	52.80	13.00	14.20	9.05	9.97
1953	3.38	3.90	73.70	171.00	366.00	206.00	169.00	791.00	156.00	127.00	52.40	11.40
1954	7.34	173.00	710.00	139.00	76.70	33.30	120.00	51.50	10.40	30.90	6.12	12.60
1955	43.20	37.50	26.60	164.00	265.00	15.20	230.00	32.10	5.88	77.70	296.00	12.40
1956	7.78	32.00	23.90	34.30	414.00	231.00	45.00	44.60	77.00	26.50	15.50	9.50
1957	8.27	4.84	61.40	9.48	82.90	88.30	224.00	17.20	27.20	8.16	23.30	54.40
1958	16.70	301.00	105.00	137.00	222.00	327.00	143.00	195.00	28.00	116.00	29.20	36.70
1959	8.78	5.81	6.97	47.20	368.00	57.20	37.20	81.60	341.00	121.00	125.00	38.30
1960	133.00	37.00	95.60	98.20	241.00	62.30	138.00	58.70	9.20	17.50	64.90	13.90
1961	6.75	5.55	12.40	119.00	819.00	457.00	158.00	48.90	28.20	166.00	81.90	127.00
1962	13.60	270.00	622.00	351.00	34.50	40.70	310.00	52.90	92.30	13.60	10.40	18.90
1963	34.10	3.22	15.30	41.00	111.00	33.10	8.36	5.60	15.90	19.70	10.70	6.61
1964	2.61	14.70	50.70	178.00	221.00	521.00	313.00	62.70	9.01	19.50	11.60	178.00
1965	47.60	64.60	184.00	137.00	344.00	161.00	25.50	20.60	6.78	17.70	19.60	21.00
1966	4.77	3.47	18.80	227.00	1026.0	135.00	123.00	28.50	14.70	13.90	25.80	28.20
1967	16.40	6.25	12.70	46.60	131.00	19.30	453.00	90.50	21.50	23.40	51.70	42.10
1968	6.46	4.76	38.70	94.80	19.33	104.00	45.30	31.70	14.80	16.00	45.80	6.09
1969	5.65	13.30	276.00	43.10	139.00	218.00	398.00	91.80	9.61	23.00	6.27	5.86
1970	21.30	4.74	12.90	33.10	41.60	156.00	61.60	16.00	28.50	12.50	25.50	17.40
1971	143.00	25.90	134.00	119.00	175.00	141.00	22.60	38.10	28.30	40.20	14.40	176.00
1972	14.50	12.20	416.00	228.00	184.00	191.00	28.80	485.00	19.40	20.30	17.10	15.20
1973	9.34	22.10	268.00	155.00	137.00	499.00	678.00	126.00	21.80	13.20	17.30	330.00
1974	24.50	175.00	226.00	351.00	276.00	274.00	242.00	521.00	29.90	18.30	41.60	39.20
1975	10.40	65.30	79.50	426.00	67.70	192.00	332.00	244.00	181.00	157.00	167.00	49.40
1976	27.50	14.00	28.90	73.60	80.60	106.00	21.50	19.10	16.50	35.50	18.60	21.00
1977	12.70	31.80	125.00	215.00	131.00	156.00	761.00	52.20	12.20	28.90	125.00	586.00
1978	85.40	234.00	239.00	298.00	144.00	86.20	63.20	184.00	22.00	40.40	102.00	32.10
1979	11.40	32.30	30.80	290.00	531.00	172.00	544.00	71.40	42.80	213.00	34.20	18.30
1980	.50	23.30	67.40	133.00	54.00	522.00	632.00	331.00	52.00	20.20	16.10	14.30
1981	23.10	[illegible]	13.10	9.58	247.00	35.90	25.20	67.30	56.30	45.90	13.40	25.30
1982	7.78	5.77	34.70	90.10	232.00	40.00	*	*	43.00	54.70	150.00	27.10
1983	*	*	*	*	*	*	*	*	*	*	*	*

* INDICATES A NO-VALUE MONTH

TABLE C-1-15

STATION 02489500 PEARL RIVER NEAR BOGALUSA, LA.

DISCHARGE-(CFS)

NORMAL MONTHLY MEANS (ALL DAYS)

YEAR	OCT	NOV	DEC	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT
1939	1504.0	1539.0	2058.0	8390.0	20850.0	24490.0	14790.0	5407.0	11400.0	4013.0	2662.0	1689.0
1940	1944.0	1447.0	1998.0	3250.0	15550.0	9266.0	15510.0	14770.0	3324.0	26570.0	8111.0	2434.0
1941	1979.0	2643.0	15490.0	12380.0	8523.0	12910.0	11110.0	4184.0	2373.0	4784.0	3585.0	1864.0
1942	1611.0	1961.0	6546.0	8083.0	7055.0	14470.0	7199.0	5698.0	2891.0	2915.0	4270.0	3189.0
1943	1995.0	2223.0	4754.0	11250.0	8298.0	21020.0	19700.0	3620.0	2346.0	2205.0	1672.0	3137.0
1944	1510.0	2654.0	2929.0	7489.0	10870.0	22430.0	35350.0	22690.0	5007.0	2486.0	3129.0	2294.0
1945	1734.0	2731.0	4484.0	10160.0	18560.0	30710.0	19790.0	7816.0	8494.0	6041.0	4127.0	2235.0
1946	2845.0	2342.0	5390.0	18250.0	31050.0	25320.0	11300.0	13800.0	12920.0	9180.0	7568.0	2768.0
1947	2035.0	5611.0	5563.0	30170.0	17560.0	19930.0	32500.0	13270.0	5342.0	3496.0	2595.0	3356.0
1948	1992.0	4544.0	11260.0	6902.0	21530.0	35450.0	14470.0	4246.0	2540.0	2433.0	2792.0	2973.0
1949	2109.0	11283.0	34840.0	31260.0	36400.0	22550.0	31690.0	14740.0	9526.0	9315.0	6417.0	6347.0
1950	3140.0	2980.0	3364.0	29720.0	28750.0	28380.0	9502.0	15960.0	5003.0	3618.0	5829.0	3340.0
1951	3215.0	2881.0	5287.0	10680.0	24870.0	15940.0	29690.0	6745.0	2946.0	2726.0	2049.0	1914.0
1952	1529.0	1713.0	4834.0	4300.0	7671.0	8912.0	7222.0	4519.0	2673.0	1773.0	1706.0	1440.0
1953	1188.0	1394.0	2240.0	7164.0	15150.0	27880.0	10380.0	36930.0	5618.0	3901.0	3574.0	2064.0
1954	1389.0	1694.0	8793.0	5636.0	7540.0	5274.0	9373.0	10090.0	2401.0	2424.0	1514.0	1246.0
1955	1408.0	1323.0	1713.0	6995.0	14960.0	10130.0	27200.0	6955.0	3374.0	3982.0	4201.0	1619.0
1956	1343.0	1424.0	2934.0	2174.0	26470.0	24230.0	21940.0	4412.0	3776.0	2046.0	1770.0	1423.0
1957	1343.0	1394.0	3463.0	3800.0	7272.0	8147.0	22810.0	5473.0	3700.0	5646.0	2252.0	3270.0
1958	5192.0	16150.0	16780.0	10550.0	12890.0	19220.0	11490.0	25650.0	7983.0	10390.0	6555.0	5004.0
1959	5352.0	2915.0	3809.0	8084.0	18860.0	10510.0	10860.0	7928.0	9046.0	4288.0	3006.0	2656.0
1960	3177.0	4437.0	6988.0	11500.0	20910.0	24480.0	9473.0	9945.0	2265.0	1852.0	4295.0	2388.0
1961	2059.0	2062.0	2390.0	7394.0	22830.0	38550.0	32270.0	4587.0	6145.0	10090.0	4514.0	3651.0
1962	2127.0	12560.0	35690.0	40220.0	21450.0	14390.0	24230.0	11480.0	4662.0	2795.0	2606.0	1996.0
1963	1991.0	1964.0	2151.0	6034.0	7641.0	6999.0	3214.0	1926.0	1651.0	2234.0	1917.0	1458.0
1964	1110.0	1233.0	2289.0	6009.0	5949.0	27820.0	25660.0	18590.0	2568.0	4684.0	3351.0	2147.0
1965	9023.0	3074.0	17820.0	8461.0	21110.0	18140.0	10300.0	2376.0	2028.0	2008.0	2454.0	3412.0
1966	3360.0	1923.0	2739.0	11310.0	34240.0	16860.0	8085.0	19960.0	4407.0	2471.0	2723.0	2532.0
1967	2197.0	2825.0	2972.0	4821.0	6674.0	4764.0	3927.0	10530.0	4891.0	3457.0	2197.0	2209.0
1968	1527.0	1702.0	12220.0	23850.0	6852.0	10960.0	15370.0	11380.0	3438.0	2309.0	2274.0	2071.0
1969	1410.0	1447.0	3578.0	7778.0	8295.0	14370.0	26300.0	11340.0	1910.0	1564.0	2352.0	1766.0
1970	1391.0	1294.0	2390.0	7881.0	4346.0	13200.0	10290.0	9905.0	2850.0	2076.0	2657.0	1945.0
1971	5288.0	3854.0	4052.0	9044.0	11370.0	32450.0	11810.0	22610.0	4178.0	4080.0	6403.0	6400.0
1972	2885.0	2322.0	27860.0	30830.0	20120.0	14950.0	6409.0	9061.0	2562.0	2555.0	2331.0	1867.0
1973	2088.0	3131.0	15900.0	28090.0	21340.0	26160.0	44320.0	24910.0	6492.0	3556.0	3752.0	3585.0
1974	2735.0	5263.0	18520.0	48900.0	46100.0	19120.0	41220.0	11340.0	7685.0	3522.0	3170.0	5287.0
1975	3372.0	4966.0	15300.0	36680.0	22170.0	26890.0	19430.0	29930.0	10480.0	5181.0	16710.0	4540.0
1976	10390.0	8584.0	7313.0	12690.0	9714.0	26590.0	31450.0	8685.0	5024.0	4266.0	2326.0	2330.0
1977	1882.0	2804.0	5682.0	20220.0	7531.0	33280.0	34160.0	5765.0	2227.0	2501.0	3410.0	4552.0
1978	5221.0	9966.0	21280.0	15240.0	20390.0	11950.0	7673.0	22820.0	6063.0	3013.0	2776.0	2397.0
1979	2121.0	1725.0	4561.0	25780.0	39840.0	38920.0	48530.0	14510.0	4775.0	9915.0	4440.0	9543.0
1980	5558.0	6477.0	23190.0	22290.0	27230.0	29960.0	67290.0	29250.0	5314.0	5350.0	2634.0	2176.0
1981	2424.0	5217.0	5409.0	3187.0	8841.0	10570.0	15680.0	4118.0	3469.0	4667.0	1968.0	2134.0
1982	1828.0	1634.0	2951.0	8427.0	18550.0	*	*	*	*	*	*	*

* INDICATES A NO-VALUE MONTH

that the Rigolets supplies 40 percent; Chef Menteur Pass supplies about 40 percent; and the IHNC supplies about 20 percent of the total salt entering the Lake.

C.1.15. The water from Lake Pontchartrain enters Lake Borgne via Chef Menteur Pass and the Rigolets and a portion enters the MR-GO via IHNC and then into Chandeleur Sound. Part of this flow enters the Mississippi Sound. In addition to the Chef Menteur Pass and the Rigolets, Lake Borgne receives fresh water from the Pearl River.

C.1.16. The Mississippi Sound receives fresh water from two major rivers (Pearl and Pascagoula), four minor rivers (Tchouticabouffa, Biloxi, Wolf, and Jordan), numerous tidal bayous, and by direct run-off. The mouth of the Pearl River is located approximately 3.6 miles west of the Mississippi Sound western limit. Pearl River, with a total drainage area of 8,700 square miles (sq. mi.), has an average flow of 9,770 cfs. The Jordan and Wolf Rivers empty into St. Louis Bay. The outflows from the Biloxi and Tchouticabouffa Rivers enter the Mississippi Sound via Biloxi Bay. Biloxi River drains an area of 271 sq. mi. and has an average flow of 192 cfs. The areal extent of the drainage basin of the Tchouticafouffa River is 242 sq. mi. and its average flow rate is 189 cfs. Pascagoula River, which flows directly into the Mississippi Sound, drains 9,400 sq. mi. and flows at an average rate of 10,000 cfs. The western end of the Sound eventually receives most of the drainage entering Lake Pontchartrain and Lake Borgne. The occasional opening of the Bonnet Carre' Spillway to reduce flood stages on the Mississippi River provides additional fresh water to the Mississippi Sound.

C.1.17. The Louisiana State University Center for Wetlands Resources conducted a Water Yield Study for the Coastal Zone. Water yield was computed using the Thornwaite-Mather Water Balance Model. The Center study, "Hydrologic and Geologic Study of the Louisiana Coastal Area"

(Gagliano et al., 1970b and f) showed considerable variation in the seasonal and annual water yield in the coastal region during the period 1945 to 1968. Water yield methodology identifies either surplus or a deficit. Water surpluses, which occur when precipitation exceeds potential evaporation and soil moisture storage, were found to be most common during the winter spring (December through May) period. Water deficits, which occur when precipitation is exceeded by potential evaporation and soil moisture, were found to usually occur during the summer-fall (June through November) period. Table C-1-16 shows the cumulative frequency, by percentage, that the seasonal surpluses and annual deficits equalled or exceeded a given value in inches at the climatic division normal stations for the period 1945-1968. The data indicate that annual deficits were generally between 2 and 5 inches and occurred about half of the years. Seasonal deficits are larger and on occasion have exceeded 10 to 15 inches.

C.1.18. The water yield analysis indicates that the coastal marshes are dominated by "feast or famine" water conditions. In term of averages, this area is about the wettest in the United States. Month by month and season by season, however, floods are intermixed with deficits which are severe enough to have ecological, economic, and agricultural significance.

TIDES

C.1.19. The tides in the estuaries are chiefly diurnal with one high and one low tide in a day. The diurnal tides range from 0.9 to 1.9 feet. The normal tide range is about 0.3 feet in Lake Maurepas, 0.5 feet in Lake Pontchartrain, 1.2 feet in Lake Borgne, 1.4 feet in Chandeleur Sound, and 0.9 feet in the Mississippi Sound. Water levels generally are at their lowest in early winter, rise through mid spring, decline through early summer, rise to a peak in late summer, and then decline through the fall. The range and height of the tide is frequently modified by the wind.

TABLE C-1-16

WATER SURPLUS AND DEFICITS

CLIMATIC DIVISON	WINTER-SPRING				SUMMER-FALL			ANNUAL			
	S ≥ 40"	S ≥ 30"	S ≥ 20"	S ≥ 10"	S ≥ 10"	S ≥ 2"	S ≥ 0"	D ≥ 15"	D ≥ 10"	D ≥ 5"	D ≥ 2"
EAST-CENTRAL											
Franklinton	4	22	65	96	29	50	67	0	0	25	67
Bogalusa	0	17	57	96	8	46	54	0	8	25	67
Covington	4	17	57	91	17	50	54	0	0	25	71
Baton Rouge	0	0	30	87	0	30	61	0	8	58	83
Hammond	0	9	52	96	13	57	70	0	0	33	71
Covington	4	17	57	91	17	50	54	0	0	25	71
Amite	4	13	52	96	21	58	71	0	4	12	75
SOUTHEAST											
New Orleans	0	13	39	83	12	54	62	0	0	25	62
Reserve	0	4	26	88	12	50	67	0	12	46	67
Pennington	0	13	57	96	25	62	75	0	4	25	54
Bay St. Louis	0	4	48	83	33	50	58	4	17	33	75
Biloxi	0	9	43	91	33	62	71	0	4	29	62

SOURCE: Hydrologic and Geologic Studies of Coastal Louisiana, Water Balance in Louisiana Estuaries, Sherwood Gagliano et al, 1970

C.1.20. Northerly winds can reduce tide levels in the Lakes Pontchartrain - Borgne system and Mississippi Sound from 1.0 feet to 5.0 feet below normal. The strong southerly and southeasterly winds associated with non-tropical storms and fronts can elevate the water levels about 1 to 5 feet above normal. The winds from tropical storms and depressions in the Gulf of Mexico can push the water to levels as high as 22 feet in the Mississippi Sound.

C.1.21. In the study area, the average elevation of the marsh is slightly less than +1 foot National Geodetic Vertical Datum (NGVD) (Nichols, 1959 and Chabreck, 1972). During the summer and autumn months, water floods the marsh to average depths of 0.2 foot. The distance water is driven inland and the rise in water levels depends on the duration and velocity of the winds and marsh elevation.

CIRCULATION

C.1.22. Water movements within the estuaries are influenced by the winds, tides, fresh water discharges, and currents in the Gulf. Currents immediately south of the barrier islands flow counterclockwise from mid-summer to early winter. From mid-winter to early summer the currents flow toward the north and east but fresh water discharges and winds modify this pattern. Current velocities usually range between 1.5 to 4.0 feet per second (fps). Velocities in the vicinity of the passes may increase to 8.5 fps due to strong tides. The littoral drift in Chandeleur Sound is generally toward the north and in Mississippi Sound the drift is toward the west. Current velocities range from 0.5 fps to 4.2 fps in the deeper passes but are greater during high water discharges and extreme tides.

C.1.23. The general water circulation pattern in Lake Pontchartrain for both flood and ebb tides is a littoral drift to the west along the south and north shores, and a return current in a broad band of water running

approximately from the northwest to the southeast. Center currents and eddies exist in the lake that may modify this pattern. Discharging Mississippi River waters through the Bonnet Carre' Spillway markedly changes the circulation pattern in the lake to easterly near the south shore and mid-lake.

C.1.24. The water circulation patterns in the Mississippi Sound are quite variable and complex and are influenced by geometry, bathymetry, and winds. The general current movement is toward the west. Bonnet Carre' Spillway openings alter the normal circulation patterns and have influenced the area as far east as a line of longitude intersecting the east end of Ship Island. The water discharged from the spillway changes circulation to an easterly flow.

HISTORICAL AND FUTURE SALINITY CHANGES

C.1.25. Authorities have recognized that seasonal saltwater intrusion is occurring in the study area. The intrusion has been observed largely through changes in vegetation patterns and types and to a lesser extent through salinity data. Historical salinity data covering the study area shows a small increase in salinity.

C.1.26. In this study, several salinity monitoring stations were analyzed (plate C-1) over the Period of Record. They are Pass Manchac near Pontchatoula, Lake Pontchartrain at Little Woods, Chef Menteur Pass near Lake Borgne, Lake Pontchartrain at North Shore, and Bayou LaLoutre at Alluvial City. Average monthly salinities for their respective Period of Record are shown in tables C-1-17, C-1-18, C-1-19, C-1-20, and C-1-21.

C.1.27. The data indicate that the lowest salinities are generally in the late spring and highest in the summer and late fall. This reflects

TABLE C-1-17

MEAN MONTHLY SALINITIES

PASS MANCHAC NEAR PONTCHATOULA, LOUISIANA

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1951	.8	.3	.4	.1	.1	.6	.7	1.0	.8	1.4	1.7	2.1
1952	2.3	1.1	.9	.7	-	.8	2.0	2.5	3.2	3.5	4.3	3.6
1953	-	1.1	.7	.7	.2	.6	.5	.8	1.1	1.3	1.6	.7
1954	.3	.6	.7	.6	.8	1.0	1.1	2.1	3.6	3.7	3.8	3.8
1955	2.[illegible]	1.7	2.3	1.7	1.6	1.7	2.6	1.7	2.1	2.3	2.4	1.9
1956	2.3	1.0	.5	.8	1.0	1.2	1.4	1.5	2.6	3.6	4.1	3.5
1957	3.2	3.7	2.4	1.3	1.6	2.5	3.4	2.8	2.9	2.5	2.0	.9
1958	.9	.3	.2	.4	.3	.4	.4	.5	.7	1.3	1.0	.9
1959	.9	.5	.4	.3	.5	.2	.4	.2	.3	.2	.4	.3
1960	.3	.3	.3	.3	.4	.4	.6	.7	.7	.6	.7	.9
1961	.6	.4	.1	.1	.2	.3	.2	.2	.3	.3	.2	.2
1962	.1	.1	.1	.1	.2	.2	.2	.4	.5	.9	1.4	1.5
1963	1.2	1.6	2.5	1.6	3.0	3.2	2.8	2.8	4.3	4.8	4.6	3.9
1964	2.2	2.3	.6	.7	.6	1.3	1.2	1.0	1.9	1.6	1.6	.7
1965	1.2	.9	.4	1.0	1.2	1.5	1.4	1.5	2.6	3.1	3.5	3.1
1966	1.7	.8	.4	.4	.5	.6	.6	.8	.9	1.3	1.5	2.5
1967	2.1	1.7	2.0	2.3	1.7	2.3	2.3	2.6	3.3	3.1	3.2	2.9
1968	2.5	2.5	2.6	2.3	2.5	2.8	2.9	2.7	2.9	3.4	3.5	2.6
1969	2.2	2.2	1.9	1.0	.9	1.4	1.7	2.1	2.1	3.0	3.3	3.5
1970	2.7	3.0	3.0	2.7	3.1	3.2	2.8	2.8	2.6	2.5	1.9	1.6
1971	1.2	1.9	1.1	1.4	1.6	1.3	1.6	1.7	1.7	1.3	1.9	1.2
1972	.3	.2	.2	.7	.7	1.0	1.6	1.6	2.7	3.5	3.4	2.2
1973	1.5	1.1	.8	.2	.1	.1	.1	.1	.5	3.0	.6	.6
1974	.7	.1	.3	.1	.4	.3	.4	.4	.8	1.0	1.1	.7
1975	.7	1.0	.8	.8	.2	.1	.1	.6	.1	2.0	.5	.6
1976	.5	.3	.5	.5	.8	1.0	.9	1.3	1.7	2.0	2.0	1.4
1977	1.1	.7	.8	3.5	.4	.9	1.7	1.4	.8	1.1	1.2	.4
1978	-	-	-	-	-	-	-	-	-	.7	1.0	.9
1979	1.5	.5	.5	.4	.1	.1	.3	.4	.6	.7	.7	.6
1980	.6	.6	.6	.1	.0	.2	.6	1.1	1.2	2.2	2.1	1.7
1981	.9	.1	1.7	2.1	2.0	1.6	2.2	1.8	2.1	-	-	-

- No Salinity Measurements Taken

SOURCE: US ENVIRONMENTAL PROTECTION AGENCY (US EPA), STORET SYSTEM

TABLE C-1-18

MEAN MONTHLY SALINITIES

LAKE PONTCHARTRAIN AT [illegible]

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1946	–	.8	.6	[illegible]	.6	.4	[illegible]	[illegible]	2.0	[illegible]	2.2	2.1
1947	1.3	1.2	.7	.6	.6	–	.5	[illegible]	2.8	[illegible]	5.1	[illegible]
1948	3.2	2.0	1.3	1.3	1.1	1.4	2.1	2.2	3.4	[illegible]	2.7	2.1
1949	1.3	1.0	.9	.7	.6	.5	.5	.4	1.9	[illegible]	2.5	[illegible]
1950	2.6	1.9	[illegible]	.2	.2	.2	.5	1.0	4.1	5.1	4.8	4.5
1951	3.8	2.9	[illegible]	3.4	1.6	1.8	2.0	2.5	3.9	[illegible]	[illegible]	[illegible]
1952	4.0	3.8	3.5	3.4	3.1	3.0	3.8	5.9	7.7	7.8	[illegible]	4.1
1953	6.5	6.3	5.1	4.1	3.9	2.4	2.5	2.4	3.3	[illegible]	4.2	3.1
1954	1.5	1.4	[illegible]	1.8	2.1	2.6	[illegible]	5.0	6.5	9.9	[illegible]	[illegible]
1955	7.0	5.7	4.8	5.0	3.9	4.4	4.8	4.7	6.0	6.0	6.6	6.4
1956	6.1	4.6	3.5	3.5	3.4	3.3	2.9	4.8	9.2	8.2	9.0	7.5
1957	6.5	6.3	5.3	5.4	4.7	4.6	4.6	4.6	5.1	5.1	3.6	4.3
1958	3.5	3.1	2.7	1.9	1.6	1.6	1.1	1.5	2.6	3.0	2.9	2.9
1959	3.0	2.7	1.7	1.3	1.3	1.2	1.2	.8	1.6	2.1	2.1	1.4
1960	2.1	1.4	1.2	.8	.9	1.7	1.9	2.8	3.1	2.8	2.5	3.3
1961	2.9	2.1	1.2	0.8	1.0	.8	.9	.8	2.6	1.9	1.8	1.2
1962	.6	.3	.5	1.2	1.2	1.2	1.4	3.1	5.2	5.1	6.0	5.9
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1964	7.5	6.9	5.3	4.0	4.3	3.9	3.9	3.8	5.4	6.3	6.6	5.6
1965	4.1	3.7	3.2	2.9	3.9	3.5	4.4	5.5	8.1	8.7	8.7	7.5
1966	5.7	6.7	1.9	2.7	2.7	3.2	3.5	3.7	4.4	5.7	5.5	6.4
1967	6.0	5.0	5.5	5.6	5.5	5.9	5.1	6.1	6.6	6.6	7.2	6.7
1968	5.6	5.1	[illegible]	5.6	5.7	5.8	5.5	5.6	6.4	7.3	7.4	7.2
1969	6.5	3.8	5.5	4.4	[illegible]	3.7	4.1	5.3	6.3	7.5	7.1	[illegible]
1970	7.0	6.2	6.1	6.5	5.6	4.9	5.6	6.2	7.0	7.2	5.9	5.2
1971	5.4	5.3	5.2	4.7	5.2	5.8	5.6	6.1	6.4	6.2	6.2	6.7
1972	3.5	2.6	3.0	3.5	2.8	4.1	4.9	5.7	7.2	7.7	8.8	7.0
1973	5.9	4.7	4.9	2.1	.2	.2	1.3	2.5	4.3	3.8	4.1	4.0
1974	2.4	2.1	1.9	2.1	2.0	1.4	1.7	3.3	4.8	5.4	5.4	4.2
1975	3.4	2.5	3.1	2.2	1.2	1.7	1.8	2.1	3.2	3.2	2.5	2.4
[illegible]	[illegible]	2.7	2.2	3.2	3.1	3.1	[illegible]	[illegible]	[illegible]	7.2	7.2	[illegible]
1977	5.7	4.9	[illegible]	4.1	3.4	3.7	4.3	5.6	6.1	4.6	5.4	[illegible]

– No Salinity Measurements Taken

SOURCE: US EPA, STORET SYSTEM

TABLE C-1-19

MEAN MONTHLY SALINITIES

CHESAPEAKE BAY ... YEAR ... BY ...

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1957	-	-	6.4	5.3	4.5	4.7	[illegible]	7.1	9.2	6.7	6.5	4.5
1958	3.7	3.1	2.8	1.9	1.6	1.5	1.7	2.5	4.9	4.2	4.4	4.3
1959	4.4	3.2	2.1	1.8	2.1	1.5	1.5	1.4	4.1	3.9	2.7	2.9
1960	2.0	1.6	1.1	1.1	1.3	3.6	5.1	6.3	5.5	5.0	4.5	5.3
1961	2.8	1.4	.8	1.0	1.5	1.8	2.5	3.5	3.5	2.9	2.6	1.4
1962	.7	.3	.7	1.2	1.7	2.1	3.5	4.4	10.2	9.1	9.8	8.4
1963	7.5	5.7	5.0	5.9	7.8	9.4	9.2	10.5	13.5	13.1	12.4	10.6
1964	8.9	6.8	5.2	3.7	3.7	3.7	4.9	4.9	7.7	7.6	7.5	5.7
1965	4.1	3.7	3.9	3.2	5.4	6.3	6.8	8.2	10.3	-	10.4	9.5
1966	5.7	4.6	2.7	4.5	3.2	3.3	3.8	5.4	6.8	8.2	8.7	8.6
1967	7.6	5.4	5.6	6.3	5.7	6.3	8.0	10.9	9.1	8.6	9.2	8.7
1968	5.4	5.0	6.5	5.8	5.6	5.2	6.4	7.5	8.9	9.2	8.8	7.9
1969	6.4	6.3	5.6	4.4	3.0	4.0	5.3	8.1	8.8	9.5	8.5	10.1
1970	6.1	7.0	6.7	6.1	6.1	5.9	5.1	8.3	9.1	8.6	6.8	7.6
1971	6.4	6.0	4.4	4.4	5.5	5.7	7.9	8.8	8.1	7.0	7.7	6.8
1972	4.1	2.7	2.7	3.7	4.3	5.6	8.9	8.3	11.4	12.5	10.0	8.0
1973	5.8	4.6	3.9	2.1	.3	.3	3.0	6.0	6.6	5.3	5.8	5.1
1974	2.9	2.0	2.2	2.3	2.2	1.7	3.5	6.1	6.6	7.3	6.6	5.2
1975	3.5	2.6	2.8	2.3	1.2	2.2	2.7	2.3	2.3	3.7	3.3	3.4
1976	3.4	3.6	4.2	3.2	3.4	3.4	4.2	8.9	10.7	10.8	10.2	6.8
1977	6.2	5.5	5.5	4.6	3.6	4.8	9.5	9.4	7.3	6.9	6.3	4.9
1978	-	-	-	-	-	-	-	-	-	-	-	-
1979	5.3	3.2	2.3	2.2	.6	2.6	3.9	4.7	5.6	6.0	6.6	5.0
1980	3.7	2.7	-	3.2	2.1	2.3	2.0	8.7	9.2	8.9	9.0	7.3
1981	9.5	8.0	-	-	-	-	-	-	-	-	-	-

- No Salinity Measurements Taken

SOURCE: US EPA, STORET SYSTEM

[illegible]	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
[illegible]	-	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1.9	[illegible]	1.2	1.2	1.5	1.5	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	2.3	1.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	2.1	[illegible]	[illegible]	.8	[illegible]	1.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	.8	1.9	[illegible]	2.5	7.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.1	7.7	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	2.7	2.2	3.3	3.3	[illegible]	11.7	[illegible]	[illegible]	4.1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	3.	1.8	3.6	[illegible]	2.5	[illegible]	-	-	[illegible]	[illegible]	[illegible]
[illegible]	-	-	-	-	-	-	-	[illegible]	[illegible]	-	-	-
[illegible]	3.[illegible]	2.2	1.9	3.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.1	[illegible]	[illegible]	.2	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	2.4	[illegible]	1.3	[illegible]	1.6	1.4	[illegible]	[illegible]	5.3	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1.7	1.7	[illegible]	1.2	1.1	[illegible]	[illegible]	[illegible]	[illegible]	3.[illegible]
[illegible]	2.[illegible]	[illegible]	2.2	[illegible]	2.3	2.2	[illegible]	[illegible]	[illegible]	2.1	2.1	2.1
[illegible]	[illegible]	3.9	3.3	2.7	2.7	3.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	3.[illegible]	2.2	1.4	1.2	[illegible]	.9	[illegible]	3.[illegible]	[illegible]	[illegible]	[illegible]	3.5
[illegible]	2.2	[illegible]	2.1	.9	.6	.8	4.6	5.6	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	6.1	6.3	[illegible]	[illegible]	6.7	5.8	5.1	7.5	7.[illegible]	-	[illegible]	-

* No Salinity Measurements Taken During 1967-197[illegible] and 197[illegible]

- No Salinity Measurements Taken

[illegible]

TABLE [illegible]-21

MEAN MONTHLY SALINITIES

BAYOU LA LOUTRE AT [illegible] CITY

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
[illegible]	-	-	-	-	-	-	-	-	-	-	12.2	12.[illegible]
[illegible]	[illegible]	[illegible]	9.2	7.1	6.1	7.6	8.3	10.0	9.4	[illegible]	8.3	7.8
1958	5.8	4.5	4.0	4.9	6.1	5.4	5.6	4.5	7.0	7.4	6.7	6.2
[illegible]	6.5	5.0	5.[illegible]	5.3	[illegible]	6.1	4.0	4.2	4.4	[illegible]	3.2	[illegible]
[illegible]	3.9	3.6	2.6	4.7	5.2	8.7	10.3	9.3	7.1	6.8	6.3	7.1
[illegible]	6.0	6.0	6.0	4.9	7.3	6.7	6.6	6.7	6.1	[illegible]	5.3	3.7
1962	2.0	3.8	5.5	7.6	10.2	10.8	13.7	17.3	15.7	[illegible]	15.6	15.5
1963	12.3	11.1	11.7	15.9	19.2	18.2	15.3	19.9	18.8	18.3	16.6	15.0
1964	11.[illegible]	10.5	8.1	7.6	[illegible]	11.1	11.1	13.0	14.0	14.0	14.9	12.1
[illegible]	[illegible]	6.9	9.8	9.[illegible]	14.6	13.5	15.8	16.2	17.3		16.8	12.8
1966	[illegible]	6.8	6.0	9.1	9.7	10.4	11.0	13.1	13.3	12.6	15.0	14.6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	9.[illegible]	10.5	13.4	13.1	13.7	13.7	14.5	15.4	14.6	14.9	16.0	13.9
1969	10.6	10.6	10.4	9.5	7.5	12.1	15.8	14.6	13.8	15.9	15.1	15.3
1970	12.2	13.4	11.3	13.2	11.8	13.6	16.0	16.4	13.2	12.5	13.0	13.3
1971	11.8	12.9	11.7	11.9	14.9	14.2	21.5	17.3	14.4	11.8	12.9	10.[illegible]
1972	7.4	5.6	8.5	11.6	9.0	13.5	18.9	19.4	17.[illegible]	20.2	15.5	13.3
[illegible]	[illegible]	[illegible]	9.2	[illegible]	[illegible]	7.2	14.4	14.1	14.4	9.4	12.3	13.1
1974	7.3	7.3	8.1	8.5	9.0	9.4	15.3	15.4	10.8	12.5	11.6	11.7
1975	7.4	9.6	8.3	6.0	5.5	7.7	11.3	11.1	8.8	7.9	6.8	9.[illegible]
1976	7.7	10.3	11.2	13.1	9.4	9.7	14.3	18.4	15.9	16.4	13.[illegible]	[illegible]
1977	12.3	[illegible]	15.7	10.6	11.2	18.6	22.9	16.5	9.3	10.8	11.[illegible]	12.7
[illegible]	10.1	4.4	5.5	5.5	1.8	6.9	13.2	13.4	9.5	13.9	11.[illegible]	11.9
1979	-	-	-	-	-	-	-	-	-	-	-	-
[illegible]	[illegible]	[illegible]	7.2	[illegible]	[illegible]	12.0	17.6	[illegible]	17.8	13.7	12.1	12.7
1981	15.9	9.6	13.[illegible]	14.2	16.3	17.1	18.9	16.9	15.8	15.9	17.[illegible]	15.1

- No Salinity Measurements Taken

SOURCE: US EPA, STORET SYSTEM

AD-A152 724 MISSISSIPPI AND LOUISIANA ESTUARINE AREAS FRESHWATER DIVERSION TO LAKE PO..(U) ARMY ENGINEER DISTRICT NEW ORLEANS LA D L CHEW APR 84 1/6

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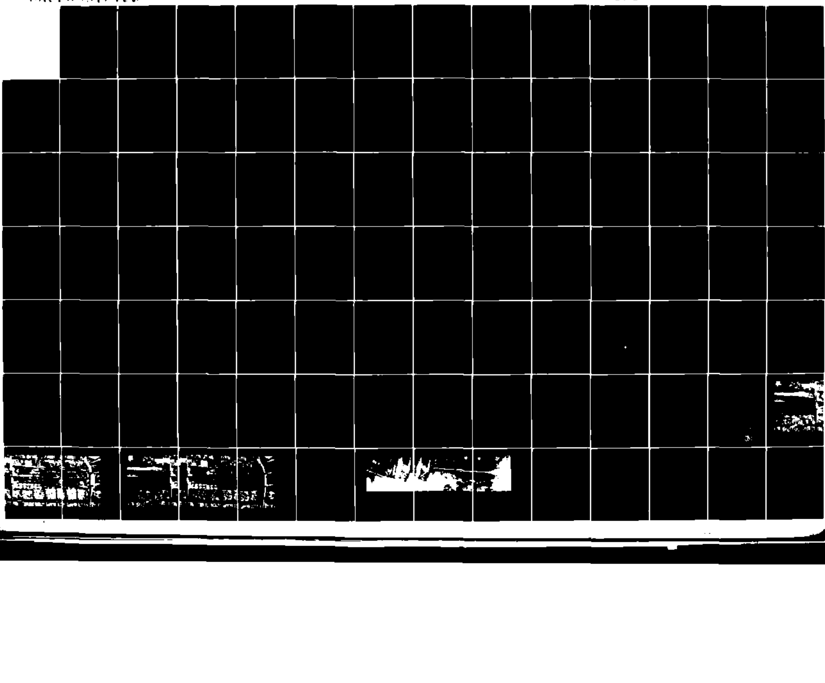

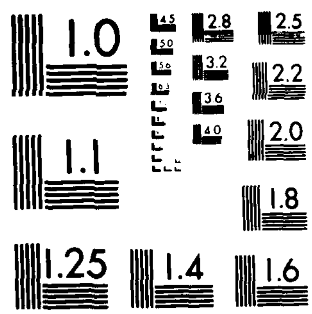

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seasonal variations in freshwater inflows from the major rivers and streams. The salinities of Lakes Pontchartrain and Maurepas normally range from fresh to brackish. During periods of extreme low flows, Lake Maurepas becomes brackish. Salinities average less than 0.2 ppt in Lake Maurepas while averaging about 1.5 ppt in Lake Pontchartrain. Lake Pontchartrain salinities range seasonally from a low of about 0.45 ppt in the late spring to a high of about 5.3 ppt in the late fall. The salinity regime is subject to drastic change during floods on the rivers and streams discharging into Lakes Maurepas and Pontchartrain, Bonnet Carre' Spillway openings, and hurricanes.

C.1.28. Salinities in Lake Borgne generally range from 2 to 15 ppt and are strongly influenced by Pearl River discharges and inflow from the Rigolets and Chef Menteur Pass. Higher salinity water from the MR-GO enters Lake Borgne through breaks in the marshes between the two water bodies.

C.1.29. Mississippi Sound salinities may vary from 2 to 30 ppt. In general salinities are highest in summer-fall during low river outflow and lowest in winter-spring during high outflow. Salinities are highest near island passes and lowest next to the coast proper, highest in deep channels and lowest at the surface. There is a noticeable westward decrease in salinity in the sound which is caused by outflow from the Pearl and Wolf Rivers and from the Rigolets. Salinities in the Sound are also decreased by Bonnet Carre' Spillway openings. The Mississippi River waters decrease salinities in the sound as far east as Ship Island during Bonnet Carre' Spillway operations.

C.1.30. Analyses of salinity data indicate that the most notable increase in average annual salinity occurred after 1963. The salinity data were further aggregated to the period prior to 1963 and to the period subsequent to 1963. Mean monthly salinities increased for virtually all months for the period subsequent to 1963. This increase

can be attributed partly to the completion of the MR-GO in 1963 which provided a major access for saline water to enter Lakes Maurepas, Pontchartrain, and Borgne. Salinity data aggregated for pre and post MR-GO conditions are shown in table C-1-22.

C.1.31. Analysis of monthly summaries of salinity for pre and post MR-GO indicates that salinities have increased by

- 1.3 ppt at Lake Pontchartrain, North Shore
- 1.8 ppt at Lake Pontchartrain, Little Woods
- 0.4 ppt at Pass Manchac near Pontchatoula
- 2.4 ppt at Chef Menteur Pass near Lake Borgne
- 4.3 ppt at Bayou LaLoutre, Alluvial City

C.1.32. The MR-GO is not the only factor that contributes to increased salinities. Between 1948 and 1970 approximately 5 sq. mi. of canals and channels were dredged in the Lake Pontchartrain Basin which provided avenues for saltwater intrusion.

C.1.33. Salinity data available indicate that the salinity regime in the study area has somewhat stabilized since 1963. Although there has been no significant increase in annual salinity subsequent to 1963, salinity variations may be considerable. During periods of low inflow salinities may increase to as high as 5.0 ppt in Lake Maurepas and as high as 20 ppt in the vicinity of the Inner Harbor Navigation Canal (Schurtz, 1982). The seasonal increases in salinity usually occur during the summer and late fall. These seasonal increases in salinities have caused habitat changes and related land loss in the wooded swamp and marsh vegetation adjacent to Lakes Maurepas and Pontchartrain. High

TABLE C-1-22

MEAN MONTHLY PRE AND POST MR-GO SALINITIES

STATION NAME	JAN PRE/POST MR-GO		FEB PRE/POST MR-GO		MAR PRE/POST MR-GO		APR PRE/POST MR-GO		MAY PRE/POST MR-GO		JUN PRE/POST MR-GO		JUL PRE/POST MR-GO		AUG PRE/POST MR-GO		SEP PRE/POST MR-GO		OCT PRE/POST MR-GO		NOV PRE/POST MR-GO		DEC PRE/POST MR-GO	
PASS MANCHAC NEAR PONTCHATOULA 1/	1.1	1.5	1.0	1.5	1.0	1.2	.8	1.3	1.0	1.1	1.0	1.5	1.0	1.6	1.2	1.7	1.7	2.0	1.8	2.2	1.8	2.1	1.2	1.8
LAKE PONTCHARTRAIN AT NORTH SHORE 2/	3.0	4.0	2.5	3.0	1.9	2.6	1.9	2.6	2.4	2.7	3.6	3.0	3.0	4.6	4.6	5.6	5.4	7.5	4.7	7.3	4.6	6.7	4.5	5.4
LAKE PONTCHARTRAIN AT LITTLE WOODS 3/	3.8	5.0	3.0	6.5	2.3	4.4	2.4	4.0	2.2	3.8	2.2	3.8	2.1	4.4	2.5	4.8	4.5	6.2	4.9	6.8	4.8	6.8	4.7	6.2
CHEF MENTEUR PASS NEAR LAKE BORGNE 4/	3.8	5.7	2.9	4.8	2.2	4.3	2.2	4.0	2.6	4.0	3.3	4.2	3.2	6.3	4.8	7.5	6.0	8.5	5.2	8.4	5.2	8.0	4.2	7.0
BAYOU LA LOUTRE AT ALLUVIAL CITY 5/	6.8	9.8	6.4	9.7	6.3	10.4	7.0	10.0	9.5	10.2	9.0	12.3	7.9	16.0	8.6	16.1	8.2	12.9	7.6	13.8	8.0	13.1	8.0	12.5

1/ Pre MR-GO 1951-1963, Post MR-GO 1963-1977
2/ Pre MR-GO 1957-1963, Post MR-GO 1963-1975
3/ Pre MR-GO 1946-1963, Post MR-GO 1963-1977
4/ Pre MR-GO 1957-1963, Post MR-GO 1963-1977
5/ Pre MR-GO 1956-1963, Post MR-GO 1963-1977

SOURCE: US EPA, STORET SYSTEM

seasonal salinities have also resulted in habitat changes and related land loss in the St. Bernard marshes between the Mississippi River and the MR-GO.

C.1.34. As previously indicated, the salinity regime in the study area has somewhat stabilized and no significant increase in average annual salinity is projected in the future for Lakes Maurepas and Pontchartrain. Salinity is expected to slightly increase in the Lake Borgne area and surrounding marshes due to future land loss in the area. Salinity would only slightly increase because the open water areas created as a result of land loss would be shallow and not lend themselves easily to saltwater intrusion. The marshes are probably a small percentage of the tidal prism and may not have a significant impact from a hydrologic viewpoint. Wide seasonal salinity variations are expected to continue into the future in response to freshwater inflows from major rivers and streams. This would result in some habitat changes and related land loss in the future.

DESIRED SALINITY CONDITIONS AND SUPPLEMENTAL FLOW REQUIREMENTS

C.1.35. Seasonal high salinity levels are occurring in the estuarine areas and causing unfavorable conditions for fish and wildlife productivity. Maintaining desirable salinity conditions can be accomplished by diverting fresh water into the estuarine areas. Having established existing and future salinity conditions estimated to occur in the basin, the ad hoc interagency group established the desirable salinity conditions favorable to fish and wildlife production. The initial objectives established in 1969-1970 were to achieve the Ford Line April through September and the Palmisano Line October through March for a 10 percent drought condition. Maximum supplemental flow requirements to achieve these objectives are shown in table C-1-23.

TABLE C-1-23

MAXIMUM SUPPLEMENTAL REQUIREMENTS

(thousands of cfs)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
12.8	15.8	19.5	21.4	21.4	21.4	21.4	21.4	21.4	13.2	9.7	12.8

Gagliano et al., 1973

C.1.36. A structure to provide the required supplemental flows during the summer and fall months would be extremely large due to lack of significant hydraulic head during the latter part of the year. Preliminary hydrologic and hydraulic investigations indicated that the structure would be prohibitively expensive and economically infeasible. In addition, the diversion of required supplemental flows may cause more adverse impacts to the environment than beneficial. The ad hoc group was reconvened in 1982 to reconsider the study objectives. Summaries of meetings and a signed Memorandum for Record of the ad hoc group containing conclusions and recommendations are Exhibit 1 of Appendix B, the Plan Formulation.

C.1.37. The ad hoc group recommended that salinity conditions similar to those that existed in the Breton Sound area preceding peak seed oyster production years should be sought for the Lake Pontchartrain Basin and western Mississippi Sound. A recent study conducted by the Louisiana Department of Wildlife and Fisheries identified optimum mean monthly salinity for oysters based on data collected over a 10-year period, 1971-1981. The optimum salinity regime is shown on plate C-2 and in table C-1-24.

TABLE C-1-24

MEAN MONTHLY OPTIMUM SALINITY

MONTH	MEAN OPTIMUM SALINITY	STANDARD ERROR*
	(ppt)	
JAN	16.4	1.04
FEB	14.4	0.79
MAR	11.6	1.02
APR	8.0	1.27
MAY	7.0	0.92
JUN	12.5	0.80
JUL	12.7	0.57
AUG	15.7	0.80
SEP	17.0	1.06
OCT	16.8	0.87
NOV	16.1	0.82
DEC	15.7	0.52

*One standard deviation from Mean Optimum Salinity

C.1.38. This optimum salinity regime should be estabilished one out of 2 or 3 years on the average to produce a good crop of seed oysters and to provide the base to significantly expand the oyster industry. In general, optimum salinity conditions for oysters are also favorable salinity conditions for most of the major estuarine species in the study area.

C.1.39. The optimum salinity conditions should be established in the St. Bernard Marshes and western Mississippi Sound where there are approximately 51,000 acres of private oyster leases east of the MR-GO; 19,000 acres in Lake Borgne, and 32,000 within the Louisiana marsh. There are about 250,000 acres of public seed grounds in the area along the fringes of the Louisiana marsh of which 12,000 acres of suitable substrate exist. About 7,500 acres of public reefs exist in the western Mississippi Sound.

C.1.40. Three locations in the St. Bernard Marshes and western Mississippi Sound were identified to establish the optimum salinity regime. This was to optimize the size of the structure and associated benefits. The three locations, #1, #2, and #3, are shown in plate C-3.

C.1.41. Supplemental flow requirements would be determined for a 50 percent drought condition or a drought that has a frequency of occurrence of one out of 2 years. Mean monthly 2, 5, and 15 ppt salinity isohalines for the 50 percent drought conditions are shown on plates C-4 through C-9.

C.1.42. Supplemental flow requirements at the three locations were determined by using a multiple regression model that related freshwater inflow to salinity. Monthly flows for five Lake Pontchartrain tributary streams (Amite, Tickfaw, Comite, Tangipahoa, and Tchefuncta Rivers) were combined to represent the flow into Lake Pontchartrain. Discharge data from the southern most station on each stream were used in this analysis. Monthly flows from the Pearl River were also used. Runoff from ungaged areas, evaporation, and wind were not used in this analysis. Salinity data collected at Treasure Pass was used in the analysis. The period of record for this station is 1970-1978. In addition, salinity data at several locations in the Orleans Parish and Biloxi marshes were obtained from the Louisiana Wildlife and Fisheries (LDWF) and the Louisiana Department of Natural Resources (LDNR). Salinity data from Pass Manchac near Pontchatoula, Lake Pontchartrain at Little Woods, Chef Menteur Pass near Lake Borgne, Lake Pontchartrain at North Shore, and Bayou LaLoutre at Alluvial City, mentioned in paragraph C.1.26., were also used in the analysis. Seasonal salinity data for the western Mississippi Sound was obtained from the Gulf Coast Research Laboratory in Ocean Springs, Mississippi.

C.1.43. The multiple regression model relating freshwater inflow to salinity was developed using a statistical package available through the U.S. Environmental Protection Agency's STORET system. Twenty sets of data representing different seasons and flow frequencies from 1970-1978 were used in the correlations. Various transformations and combinations were explored with salinity and discharge data set. The multiple regression model with the highest correlation coefficient was used to determine supplemental freshwater flows.

The multiple regression model is shown below:

$$S = B_1 \, LN(A) + B_2 \, LN(C) + I$$

Where, S = Average monthly salinity, PPT

A = Previous month's discharge for Lake Pontchartrain (cfs) including any diversions, plus previous months discharge for Pearl River (cfs), plus current month's discharge for Pearl River (cfs)

C = Current month's discharge for Lake Pontchartrain (cfs) including any diversions

B_1 = -3.8635 Model Coefficient

B_2 = -1.0607 Model Coefficient

I = 77.78 Intercept Value

C.1.44. The coefficient of determination (R^2), which is the percent variation in the dependent variable explained by the model, is 0.8 for this model. The F value, which is the ratio of the regression mean square to the error mean square, reflects the significance of the results. There is only a 1 percent chance of a value of F_{17}^{2} (2 degrees

of freedom due to the regression and 17 degrees of freedom about the regression residual) exceeding 6.1. The computed F value for this regression, 28.9, reveals strong evidence of the existence of a linear regression.

C.1.45. Pearl River discharges were specifically identified as input to the regression equation because of the strong influence it has in determining salinities in Lakes Pontchartrain and Borgne. High discharges of the Pearl River usually occur from February to April. Low discharges occur from August to October. Plots of Pearl River discharges against the salinity records from Lake Pontchartrain indicate that low salinity periods correspond to high discharge of the Pearl River. Significant quantities of water from the Pearl River enter Lake Pontchartrain through the Rigolets and to a lesser extent Chef Menteur Pass. For Lake Pontchartrain, the mean flushing time has been estimated at 30 days based on the amount of time required for the Lake to return to near normal conditions after operation of the Bonnet Carre' Spillway.

C.1.46. Coastal Environments, Inc. completed a report entitled "Recommendations for Freshwater Diversion to Louisiana Estuaries East of the Mississippi River" in June 1982. The report was prepared for the Louisiana Department of Natural Resources. In that report a similar approach, to the one used in this study was taken to determine freshwater supplemental requirements. A multiple linear regression model expressing average salinity in a given month as a function of total freshwater inflow during that month and of some additional variables to account for the effect of antecedent conditions was used in the analysis. The multiple linear regression models produce similar freshwater supplemental flows as the model used in this study. The study recommendation was that the freshwater diversion structure would be located just west of the Bonnet Carre' Spillway. The control structure would be designed to divert a maximum flow of 30,000 cfs during the month of April during a 50% drought condition.

C.1.47. Monthly discharges from major rivers of 50 percent frequency were used in the model to generate monthly median salinity concentrations to determine which months required salinity alteration. Monthly supplemental flow requirements for the three locations were determined by solving the regression model for additional flow with the desired salinity input as the salinity concentration value. The results of these computations are shown in table C-1-25.

C.1.48. These supplemental flow requirements shown in table C-1-25 represent fresh water diverted directly to Lakes Maurepas or Pontchartrain. At Location #1 optimum salinity conditions exist most of the time, therefore, no supplemental fresh water would be required. To achieve optimum salinity conditions at Location #2, supplemental fresh water must be diverted March through November with the maximum diversion of 30,000 cfs in April. A maximum supplemental flow of 180,000 cfs in April would be required to established the optimum salinity regime at Location #3; 102,000 cfs would be required in March. The large increase in supplemental flow requirements between Locations #2 and #3 is due to the large amount of open water adjacent to Location #3 in the Chandeleur Sound that would constantly reduce the effects of the freshwater. A structure to divert 180,000 cfs would be approaching the size of the Bonnet Carre' Spillway and would be extremely expensive. In addition Lakes Pontchartrain and Borgne would be overfreshened most of the year causing adverse impacts to estuarine species. Consequently, it was concluded that the diversion structure, channel and associated works should be designed to convey the supplemental flow requirements to achieve the optimum salinity regime at Location #2. The with-project salinity that would be attained at Location #2 is shown on table C-1-26. Mean monthly with-project salinity isohalines (2 ppt, 5 ppt, and 15 ppt) are shown on plates C-10 through C-15.

TABLE C-1-25

Maximum supplemental flow requirements to establish optimum salinity conditions at Locations 1, 2, and 3.

MONTH	MEAN OPTIMAL ALLOWABLE SALINITY AT LOCATIONS 1, 2, & 3	MAXIMUM SUPPLEMENTAL FLOW REQUIREMENTS		
		LOCATION #1	LOCATION #2	LOCATION #3
JAN	15-17	0	0	7,600
FEB	13-15	0	0	10,700
MAR	11-13	0	10,800	102,000
APR	7-9	0	30,000	180,000
MAY	6-8	0	16,700	20,800
JUN	12-14	0	14,600	30,000
JUL	12.5-13.5	0	3,200	15,300
AUG	15-17	0	2,600	11,300
SEP	16-18	0	2,000	12,000
OCT	16-18	0	5,500	13,300
NOV	15-17	0	3,200	26,000
DEC	15.5-16.5	0	0	0

C.1.49. Supplemental freshwater quantities diverted at sites at or below the Inner Harbor Navigation Canal Lock (IHNC) would be greater than those diverted at sites with receiving water bodies, Lakes Maurepas or Pontchartrain. Significant quantities of fresh water would be lost from the system via the MR-GO. A conservative estimate of the amount of fresh water required to be diverted at these sites is 1.5 times the flow required at sites that divert water to Lakes Maurepas or Pontchartrain. Supplemental flow requirements for sites at or below the IHNC to attain optimum salinity regime at Locations #2 and #3 are shown in table C-1-27.

TABLE C-1-26

Supplemental Flow Requirements to Achieve Optimum Salinity Conditions at Location #2

MONTH	SUPPLEMENTAL FLOWS (CFS)	MEAN WITH-PROJECT SALINITY (PPT)
JAN	0	14.2
FEB	0	12.2
MAR	10,800	9.6
APR	30,000	8.0
MAY	16,700	8.0
JUN	14,600	12.5
JUL	3,200	13.0
AUG	2,600	16.0
SEP	2,000	17.0
OCT	5,500	17.0
NOV	3,200	16.0
DEC	0	16.0

TABLE C-1-27

Supplemental flow requirements for sites at or below the IHNC to attain optimum salinity regime at Locations #2 and #3.

MONTH	MEAN OPTIMAL ALLOWABLE SALINITY AT LOCATIONS #2 AND #3	MAXIMUM SUPPLEMENTAL FLOW REQUIREMENTS	
		LOCATION #2	LOCATION #3
JAN	15-17	0	11,400
FEB	13-15	0	16,050
MAR	11-13	16,200	153,000
APR	7-9	45,000	270,000
MAY	6-8	25,000	31,200
JUN	12-14	21,900	45,000
JUL	12.5-13.5	4,800	22,950
AUG	15-17	3,900	16,950
SEP	16-18	3,000	18,000
OCT	16-18	8,200	19,950
NOV	15-17	4,800	39,000
DEC	15.5-16.5	0	0

be used for a portion of the distance to Lake Pontchartrain. Supplemental flow requirements are smaller than those required at the Riverbend or IHNC sites. A structure could be designed at the site location to pass the maximum flow of 30,000 cfs without any significant design problems. Supplemental flows required at the Bonnet Carre' site to achieve the desired salinity in the St. Bernard marshes are shown in Table C-1-34.

C.1.66. Seventeen of the 350 bays in the spillway structure would have to be modified for freshwater diversion. The modification would increase the cost $5,200,000. The cost is increased because the existing gates in the structure must be removed and reconstructed for freshwater diversion, a cofferdam is needed to protect the work site from Mississippi River overflow, the structure above the culverts will have to be reinforced concrete instead of embankment, and an additional bridge will have to be built over the conveyance channel to provide continued access to the road on the landside of the structure. Placing the structure in the spillway would decrease the cost of relocation by an estimated $1,131,000, levee costs by $761,000, and land and damages by $4,027,000. These decreases in costs were taken into consideration in the $5,200,000 additional required to place the structure in the spillway. A summary of first costs for the freshwater diversion structure and associated works within the spillway structure is shown below:

Lands and Damages (recreation sites)	$42,200
Relocations	9,093,000
Channel and canals	17,529,000
Recreation facilities (6 sites)	700,700
Diversion structure	
within spillway structure	30,[illegible],352
Monitoring program	5,016,000
Total Cost	$62,971,252
Total Rounded	$63,000,000

TABLE C-1-33

Supplemental flows that could be diverted through a culvert system adjacent to the existing lock.

MONTH	AVERAGE HEAD DIFFERENTIAL	SUPPLEMENTAL FLOW (CFS)
JAN	5.0	6,000
FEB	8.0	7,600
MAR	10.5	8,700
APR	12.4	9,500
MAY	11.5	9,100
JUN	7.0	7,100
JUL	4.5	5,700
AUG	3.0	4,600
SEP	2.6	4,300
OCT	2.5	4,200
NOV	2.5	4,200
DEC	2.8	4,500

For a maximum differential head of 18.6 feet the flow would be 11,600 cfs.

C.1.64. The supplemental flows that would be diverted through the culvert are insufficient to establish the desired salinity regime at Location #2. The IHNC site was eliminated from the hydraulic analysis.

C.1.65. Bonnet Carre'. The Bonnet Carre' site is the best site for freshwater diversion from a hydraulic viewpoint. The conveyance channel would be shorter and the existing borrow channel in the floodway could

TABLE C-1-32

SUPPLEMENTAL FLOWS THAT COULD BE DIVERTED
THROUGH THE EXISTING LOCK CULVERT SYSTEM

MONTH	SUPPLEMENTAL FLOW (CFS)
JAN	1,890
FEB	2,369
MAR	2,892
APR	3,047
MAY	2,821
JUN	1,916
JUL	1,464
AUG	1,010
SEP	-----
OCT	553
NOV	903
DEC	1,237

from the canal end of the structure. An outlet channel extending to the north end of the existing lock, approximately 800 feet in length would be required. Along the eastern side of the outlet channel, extension of the floodwall protection back to the diversion structure would be required. Top elevation of that floodwall is 14 feet NGVD. The structure would have a maximum capacity of 11,600 cfs without adversely affecting navigation. Monthly supplemental flows that could be diverted based on average monthly head differentials are shown in table C-1-33.

TABLE C-1-31

VOLUME OF FRESHWATER AVAILABLE FOR DIVERSION THROUGH THE VARIOUS SIZE LOCKS AND GATES CONSIDERED AT THE LNC SITE

DEVELOPMENT SCHEME NO.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
						CU FT x 10^6						
1	253	405	532	628	582	354	228	152	132	127	127	142
2	469	750	984	1,163	1,078	656	422	281	244	234	234	234
3	253	405	532	628	582	354	228	152	132	127	127	142
4	700	1,118	1,467	1,732	1,607	978	629	419	363	349	349	391
5	700	1,118	1,467	1,732	1,607	978	629	419	363	349	349	391
6	968	1,548	2,032	2,400	2,225	1,355	871	581	503	484	484	542
7	968	1,548	2,032	2,400	2,225	1,355	871	581	503	484	484	542
8	900	1,440	1,890	2,232	2,070	1,260	810	540	463	450	450	504
9	5,280	6,930	8,160	9,090	8,670	6,390	4,980	3,990	3,690	3,630	3,630	3,840
10	6,060	7,920	9,420	10,470	9,340	7,320	5,730	4,590	4,260	4,170	4,170	4,410
11	7,500	9,720	11,370	12,570	12,030	9,030	7,080	5,700	5,280	5,190	5,190	5,490
12	8,250	10,800	12,690	14,070	13,440	9,990	7,800	6,270	5,820	5,670	5,670	6,030
13	10,230	13,260	15,540	17,160	16,380	12,330	9,660	7,800	7,230	7,050	7,050	7,500
14	1,170	1,470	1,710	1,860	1,770	1,380	1,110	900	840	840	840	870
15	1,620	2,040	2,340	2,550	2,460	1,920	1,530	1,260	1,170	1,140	1,140	1,200
16	480	630	720	780	750	570	450	390	360	330	330	360
17	1,860	2,340	2,670	2,910	2,790	2,190	1,740	1,440	1,320	1,290	1,290	1,380
18	2,340	2,970	3,390	3,690	3,540	2,760	2,190	1,830	1,680	1,620	1,620	1,740
Required Supplemental Volume	-	-	4.15×10^{10}	1.17×10^{11}	6.48×10^{10}	5.68×10^{10}	1.2×10^{10}	1.01×10^{10}	7.78×10^{9}	2.15×10^{10}	1.24×10^{10}	-

assumed. The assumption made in development schemes 9-18 is that water would be diverted when traffic permited for a period of 2 hours per day. The volumes available for diversion through the proposed combinations were less than the required supplemental flow (table C-1-27). The volumes of flow that could be diverted under the proposed combinations are shown in table C-1-31.

C.1.60. In no month was the volume of water available large enough to meet the supplemental flow requirements. This development scheme was eliminated from consideration because the required supplemental flows could not be provided and none of the proposed combinations had any good prospects of being implemented in the future.

C.1.61. Secondly, the existing lock culvert system would be used to divert fresh water. No modification would be made to the lock. The computed supplemental flows that could be diverted are shown in table C-1-32.

C.1.62. The supplemental flows are of such a small magnitude that the discharges would not have a significant effect on establishing the optimum salinity regime at Location #2. Thus, this development scheme was eliminated from consideration.

C.1.63. Within the existing lock rights-of-way, area is available to construct a separate freshwater diversion structure. It was determined that a structure consisting of three 10-foot diameter concrete culverts could be placed in the existing rights-of-way. The structure would be located on the east side of the existing lock (plate C-19). The invert elevation of the culverts could be -12.0 feet NGVD. Provision for positive cutoff by the use of vertical lift gates would be on the Mississippi River side of the structure. The length of the structure would be 300 feet, with 12 inches of riprap extending 50 feet outward

TABLE C-1-30 (CONTINUED)

COMBINATIONS OF TYPES AND SIZES OF LOCKS CONSIDERED
AT EXISTING INDUSTRIAL LOCK LOCATION

DEVELOPMENT SCHEMES	SIZE OF LOCK	OPERATIONAL MODE	TYPES OF GATES
15	40 x 150 x 1200 or 50 x 150 x 1200 (New locks)	Leaving valves/ culverts gates open when traffic permits, for 2 hours - upstream gate is closed, down-stream gate is open, both valves are open	Miter gates
16	34.5 x 75 x 675 (Existing lock)	Leaving valves/ culverts gates open when traffic permits, for 2 hours - upstream gate is closed, downstream gate is open, both valves are open	Miter gates
17	34.5 x 75 x 1200 (extension) or 12 x 75 x 1200	Leaving valves/ culverts gates open when traffic permits, for 2 hours - upstream gate is closed, down-stream gate is open, both valves are open	Miter gates
18	12 x 75 x 1200 New barge lock in conjunction with and along side existing lock	Leaving valves/ culverts gates open, when traffic permits, for 2 hours - upstream gate is closed, downstream gate is open both valves are open	Miter gates

TABLE C-1-30 (CONTINUED)

COMBINATIONS OF TYPES AND SIZES OF LOCKS CONSIDERED
AT EXISTING INDUSTRIAL LOCK LOCATION

DEVELOPMENT SCHEMES	SIZE OF LOCK	OPERATIONAL MODE	TYPES OF GATES
10	40 x 100 x 1200	Leaving lock gates half open for a period of 2 hours when traffic permits	Vertically pinned sector gate and rising sector gate
11	50 x 110 x 1200	Leaving lock gates half open for a period of 2 hours when traffic permits	Vertically pinned sector gate and rising sector gate
12	40 x 150 x 1200	Leaving lock gates half open for a period of 2 hours when traffic permits	Vertically pinned sector gate and rising sector gate
13	50 x 150 x 1200	Leaving lock gates half open for a period of 2 hours when traffic permits	Vertically pinned sector gate and rising sector gate
14	34.5 x 110 x 1200 or 40 x 110 x 1200 or 50 x 110 x 1200 (New locks)	Leaving valves, culverts, and/or gates open when traffic permits for 2 hours - upstream gate is closed, downstream gate is closed downstream gate is open, both valves are open	Miter gates

TABLE C-1-30

COMBINATIONS OF TYPES AND SIZES OF LOCKS CONSIDERED
AT EXISTING INDUSTRIAL LOCK LOCATION

DEVELOPMENT SCHEMES	SIZE OF LOCK	OPERATIONAL MODE	TYPES OF GATES
1	34.5 x 75 x 640	Normal locking opn	Miter gates
2	34.4 x 75 x 1200	Normal locking opn	Miter gates
3	12 x 75 x 1200 in conjunction and along side the existing lock	Normal locking opn	Miter gates
4	34.5 x 100 x 1200 or 40 x 110 x 1200 or 50 x 110 x 1200 (New locks)	Normal locking opn	Miter gates
5	34.5 x 100 x 1200 or 40 x 100 x 1200 or 50 x 110 x 1200 (New locks)	Normal locking opn	Vertically pinned sector gates using thru gate end filling system
6	40 x 150 x 1200 or 50 x 150 x 1200 (New locks)	Normal locking opn	Miter gates
7	40 x 150 x 1200 or 50 x 150 x 1200 (New locks)	Normal locking opn	Vertically pinned sector gates using thru gate end filling system
8	40 x 180 x 1200 or 50 x 150 x 1200 (New locks)	Normal locking opn	Rising Radial gates, orifice flow
9	34.5 x 140 x 1200	Leaving lock gates half open for a period of 2 hours when traffic permits	Vertically pinned sector gate and rising sector gate

MONTH	SUPPLEMENTAL FLOW REQUIREMENTS (CFS)
AUG	2,600
SEP	2,000
OCT	5,500
NOV	3,200
TOTAL	13,300
AVERAGE	3,325

$$3{,}325 \text{ cfs} \times 122 \text{ days} \times 24 \text{ hrs/day} \times 60 \text{ min/hr} \times 60 \text{ sec/min} =$$

$$3.5048 \times 10^{10} \text{ cu. ft.}$$

$$\frac{3.5048 \times 10^{10} \text{ cu. ft.}}{43{,}560 \text{ cu. ft./acre ft.}} = 804{,}595 \text{ Acre Feet}$$

$$\frac{804{,}595 \text{ Acre Feet}}{24{,}000 \text{ Acres}} = 33.5 \text{ ft.}$$

This is impractical because the hurricane protection levees would have to be raised and pumping stations and floodgates that provide drainage to the developed areas would have to be modified. The Riverbend site was eliminated from detailed analysis because the required supplemental flows to achieve the optimum salinity regime could not be diverted and public opposition to the diversion site. As a result Alternative Plan Nos. A, B and C were eliminated.

C.1.59. Inner Harbor Navigation Lock Site. At the IHNC site, three development schemes were considered due to the uncertainty of the study recommendations that may come from the "Mississippi River - Gulf Outlet, New Lock and Connecting Channels" study. Detailed site selection studies are underway and a study completion date has not been determined. The IHNC site is shown on plate C-18. The first 18 combinations of types and sizes of locks using various operational modes were considered at the existing lock location. The 18 combinations are displayed in table C-1-30. For development schemes 1-8, the volume of water that would be diverted during one normal locking operation was calculated. Thirty locking operations per 24-hour period were

TABLE C-1-29

MISSISSIPPI RIVER 50 PERCENT EXCEEDANCE STAGES
AT RIVERBEND SITE-MILE 83 AHP

MONTH	50 PERCENT EXCEEDANCE STAGE
JAN	4.6
FEB	6.4
MAR	8.8
APR	9.4
MAY	10.5
JUN	5.4
JUL	3.1
AUG	2.1*
SEP	1.7*
OCT	1.8*
NOV	1.9*
DEC	2.2*
Landside means high tide, Shell Beach at MR-GO	2.0
Head loss through the structure	0.3
TW	2.3

* During these months the river stages are lower than the landside stages and no water can be diverted.

August, September, October, and November. The impoundment area would be about 24,000 acres. It was determined that the depth of the impoundment would exceed 30 feet to allow the required water for the 4-month period. Computations to make this determination are shown below:

TABLE C-1-28

ALTERNATIVE PLANS RECOMMENDED FOR STUDY IN THE INTERMEDIATE STAGE

ALTERNATIVE PLAN NO.	STRATEGY	DIVERSION SITE
A	Divert at one location below New Orleans	Riverbend
B	Divert one location above New Orleans and one location below New Orleans	Bonnet Carre' - 75% of supplemental flow Riverbend - 25% of supplemental flow
C	Divert at one location above New Orleans and one location below New Orleans	Bonnet Carre' - 50% of supplemental flow Riverbend - 50% of supplemental flow
D	Divert at one location in New Orleans	IHNC
E	Divert at one location above New Orleans and one location in New Orleans	Bonnet Carre' IHNC
F	Divert at one location above New Orleans	Bonnet Carre'

PROJECT SITE ANALYSIS

C.1.56. Based on the predicted need for freshwater inflows to the Lake Pontchartrain Basin and western Mississippi Sound, 13 potential diversion sites that are representative of all possible sites in the study area were identified. The most practicable upstream site was located at mile 214.8 AHP at Bayou Manchac and the site nearest the mouth of the river was Bayous Terre Aux Boeufs and LaLoutre at Mile 82.0 AHP. Preliminary evaluation of the 13 sites is presented in the Plan Formulation Appendix. The 13 sites were screened to 3 sites for detailed analysis. The sites are Riverbend, Inner Harbor Navigation Canal, and Bonnet Carre'. The sites were used to formulate 6 alternative plans that are shown on table C-1-28.

C.1.57. Riverbend. Supplemental flow requirements for Riverbend site are shown on table C-1-27. The plan for the site consist of a control structure at mile 83 AHP, a conveyance channel and floodgates at the intersection of the conveyance channel with the hurricane protection levee adjacent to the MR-GO. The site plan is shown on plate C-16. A channel would be excavated from the control structure through the hurricane protection backlevee across the marshes to the MR-GO. Hydraulic analysis at the Riverbend site indicates that the hydraulic head available would only allow water to be diverted January to July. The 50 percent exceedance stages by month used to make that determination are shown in Table C-1-29.

C.1.58. Investigations were made to determine whether an impoundment could be created in the marshes encompassed between the hurricane back protection levee and the marshes and the hurricane protection levee adjacent to the MR-GO and GIWW (see plate C-17). The water would be impounded in the area when the head is available and released during

C.1.52. In the partly mixed channel, tidal currents are sufficient to produce appreciable vertical mixing of the salt water and fresh water. Since the current normally flows both flood and ebb in the partly mixed type, the salt water advances and retreats with each rise and fall of the tide. The interface between the fresher water in the surface strata and the saltier water underneath is not so well defined as in the highly stratified type, however, the presence of the "interface" is indicated by a more or less pronounced transition in the vertical salinity profile or the vertical velocity profile.

C.1.53. In the well mixed channel, the tidal forces predominate over the fresh water inflow to such an extent that the fresh and salt water are fairly well mixed throughout the vertical. An embryo "interface," however, can usually be detected in certain regions of the channel as a transition of the vertical salinity profile as well as the vertical velocity profile.

C.1.54. A channel may be changed from highly stratified to partly mixed or well mixed by reduction of the freshwater discharge. Conversely, one may be changed from well mixed or partly mixed or highly stratified by increasing the fresh water discharge. There are cases of record in which the diversion of fresh water from one tributary watershed to another has produced drastic changes in estuary mixing characteristics with sometimes disastrous results (Ippen, 1966).

C.1.55. Minor changes in mixing types are being constantly affected by the deepening and other improvement of estuary channels for navigation. As channels are dredged deeper, the salt water penetrates further into the estuary and the degree of vertical stratification of the fresh and salt water is increased because of reduced tidal current velocities.

C.1.50. The basis for the estimate is that fresh water discharged into canals and channels such as MR-GO, under certain conditions, causes significant changes in the duration of tidal currents in several ways. First, the fresh water entering the canal and channels during the flood current phase reduces the amount of water which would otherwise flow in from the gulf since a portion of the potential tidal prism is filled with fresh water. Likewise, the fresh water increases the outflow during the ebb current phase. This reduction in inflow and increase in outflow results in a new flow in the ebb direction, since more water flows out of the channel during ebb than flows in during flood. Second, the fresh water which is contributed to the channel, being of lesser density than sea water, tends to flow through the channel and out to sea in the surface strata. Conversely, the heavier sea water tends to occupy the lower strata. In the absence of vertical mixing, for weak tidal flow, the fresh water flows out to sea in a relatively thin layer at the surface. This gives a large predominance to the surface ebb current over the surface flood current while the saline water in the lower strata oscillates back and forth with the tide with little or no net flow in either direction.

C.1.51. The amount of fresh water which the MR-GO receives from freshwater diversion and the degree to which it mixes with the salt in the channel are of prime importance in establishing the vertical pattern of the system. Since the diversion flows would vary widely from month to month three conditions may exist in the channel. The channel may be highly stratified, partly mixed, or well mixed. Where the inflow of fresh water is large with respect to the tidal discharge, the fresh and salt water tend to remain separate, with the fresh water flowing out to sea over the top of the saltwater layer and the saltwater layer intruding underneath the fresh water into a rough wedge shape. The extent to which the saltwater wedge penetrates into the channel is thus a function of the channel depth, the freshwater discharge, and the density differential between the salt and fresh water. These are all conditions typical of a highly stratified channel.

TABLE C-1-34

Required supplemental flows at the Bonnet Carre' site with desired with-project salinity.

MONTH	SUPPLEMENTAL FLOW	DESIRED SALINITY @ LOCATION #2	WITH-PROJECT SALINITY @ LOCATION #2
JAN	------	15-17	14.2
FEB	------	13-15	12.2
MAR	10,800	11-13	9.6
APR	30,000	7-9	8.0
MAY	16,700	6-8	8.0
JUN	14,600	12-14	12.5
JUL	3,200	12.5-13.5	13.0
AUG	2,600	15-17	16.0
SEP	2,000	16-18	17.0
OCT	5,500	16-18	17.0
NOV	3,200	15-17	16.0
DEC	-------	15.5-16.5	16.0

Therefore, it was determined that the freshwater diversion structure should be just upriver of the spillway structure.

C.1.67. The Bonnet Carre' site plan is shown in plate C-20. Design and cost estimates were developed for the Bonnet Carre' site and are contained in Section 2 of this appendix.

IMPACTS OF BONNET CARRE' FRESH WATER DIVERSION SITE

EFFECTS ON WATER SUPPLY

C.1.68. There are no anticipated impacts of freshwater diversion on water supply. Under the diversion plan the structure would be closed at any time public water supplies are threatened by saltwater intrusion. Normally the effect of this diversion on the movement of saltwater intrusion in the river is insignificant and would not cause additional impacts on the water supply systems of downstream users.

EFFECTS ON NAVIGATION

C.1.69. The effect on shoaling in the river immediately downstream of the diversion site will be insignificant because of the naturally deep river channel. Any increase in dredging in Southwest Pass as a result of these diversions would be negligible.

EFFECTS ON FLOOD CONTROL

C.1.70. The effects of Bonnet Carre' operation on stages in Lake Pontchartrain were evaluated as part of a physical model study made by the U.S Army Engineer Waterways Experiment Station, Vicksburg, Mississippi in 1963. That report is published under the title "Effects on Lake Pontchartrain, LA of Hurricane Surge Control Structures and Mississippi River - Gulf Outlet Channel." The report indicates that for the passage of flows at or near the design value of 250,000 cfs, the operation of the spillway would increase stages in Lake Pontchartrain by about 0.7 foot for average high water stages in Lake Borgne. An analysis of the effects of Bonnet Carre' on lake sites during the 1973 and 1979 operation indicates that the model results are generally valid.

C.1.71. The events of the 1973 and 1979 operations are of particular interest insofar as operational effects are concerned. The events also reflected a combination of spillway operational effects with rather extreme local meteorological conditions, including strong southeast winds conducive to the generation of very high tides in the lake, and excess rainfall and runoff. The salient information to be drawn from these events is discussed below.

C.1.72. During the 1973 Mississippi River flood, the Bonnet Carre' Spillway was operated from 8 April through 21 June. The structure was fully open from 11 April through 31 May. Unusually strong (35 m.p.h.) southeasterly winds began on 15 April and continued through 24 April and heavy rains fell over the Lake Pontchartrain basin on 16 and 17 April. The highest stage recorded in Lake Pontchartrain during the 1973 flood was 5.0 feet above mean sea level which occurred on 18 April. The highest stage in the Gulf of Mexico and Lake Borgne (4 feet above mean sea level) also occurred on that same day. When the period of high winds ended, the lake level began to fall and by 29 April had returned to a near normal stage of 1.7 feet above mean sea level (about 0.7 foot above normal lake level) where it remained until the end of May. The maximum discharge of 195,000 cubic feet per second (cfs) from Bonnet Carre' Spillway did not occur until 14 May, about 15 days after the lake had returned to near normal stages. Consequently, the net effect from Bonnet Carre' operation was determined to be no more than a 0.7 foot rise in Lake Pontchartrain stages. The additional 3.3 feet of rises in lake and gulf levels were due to strong southeast winds for a sustained period.

C.1.73. During the 1979 Mississippi River flood, the Bonnet Carre' Spillway was operated from 17 April through 23 May. The structure was fully open from 23 April through 7 May. An unusual sequence of weather systems occurred between 18 and 28 April raising the stages in the Gulf

of Mexico and Lake Borgne by 3.5 feet in 72 hours between 20 to 23 April and consequently raising the Lake Pontchartrain stages by 3 feet. Measured discharges through Bonnet Carre' ranged from 111,000 cfs to 191,000 cfs during this period. In addition, heavy rainfall in the Lake Pontchartrain Basin caused some increase in stages. A current meter in the Rigolets measured constant inflows into Lake Pontchartrain of 3 to 3.5 fps during the same period. The major contribution to the high stages in Lake Pontchartrain was the high stages in the gulf.

C.1.74. Under the assumption that increased stages in Lake Pontchartrain due to Bonnet Carre' operations under normal climatologic conditions are directly proportional to discharge, the maximum increase in stage for each diversion month is shown in table C-1-35.

TABLE C-1-35

Estimated increase in Lake Pontchartrain stages due to diverted fresh-water.

MONTH	MAXIMUM BONNET CARRE' DIVERSION (CFS)	COMPUTED STAGE INCREASE (FT)
JAN	0	0
FEB	0	0
MAR	10,800	0.03
APR	30,000	0.08
MAY	16,700	0.05
JUN	14,600	0.04
JUL	3,200	0.01
AUG	2,600	0.01
SEP	2,000	0.01
OCT	5,500	0.02
NOV	3,200	0.01
DEC	0	0

SEDIMENT TRAP

C.1.75. At the Bonnet Carre' site, a sediment trap will be placed 3,500 feet downstream of the diversion structure. The bottom of the trap will be 780 feet wide at elevation -36.0 feet with sideslope 1V on 3H from elevation -36.0 feet to elevation -21.0 feet. The length of the trap is 1,450 feet. The top width of the channel is 1,020 feet at elevation 4.0 feet. The capacity of the sediment trap is approximately 665,000 cubic yards.

SEDIMENTATION

C.1.76. The major sediment sampling station on the Mississippi River in the vicinity of the proposed diversion site is the Mississippi River at Tarbert Landing, Mississippi, station with a period of record 1950 to the present (1982). For a period of record, Water Years 1970-1979, the average annual suspended sediment load at this station is 185 million tons with a sand-silt ratio of about 25 percent sand and 75 percent silt. The sand grain size fractions for the suspended load are approximately the following: 54 percent very fine sand, 39 percent fine sand, 5 percent medium sand, and 1 percent coarse sand. Based on the monthly average of the measured suspended sediment load for Water Years 1970-1979 and the proposed diversion schedule, 109 million tons of sediment will be diverted at the Bonnet Carre' site during the 50-year project life.

C.1.77. The sediment trap in the outflow channel of the diversion structure has been designed to remove the sand load. The capacity of the trap would be reached when the maximum supplemental flows have been passed through the structure for 2 years. The silt and clay load, estimated to be 1.26 million cubic yards annually, can be expected to enter Lake Pontchartrain. Allowing for an average sediment retention

rate of 70 percent and a 10 percent loss in volume from subsidence, deposition in Lake Pontchartrain would cover about 24,600 acres to a depth of one foot, over a 50-year project life. This is about 2% of the lake's bottom area.

SECTION 2. DESIGN AND COST ESTIMATES

GENERAL

C.2.1. This section contains design information and cost estimates on the Bonnet Carre' site for diverting Mississippi River flow to the Lake Pontchartrain Basin and western Mississippi Sound. The plan of improvement includes a control structure adjacent to the river, conveyance channels, appurtenant works, and recreation facilities.

C.2.2. Diversion flows and structure site were determined from hydrologic and hydraulic analyses discussed in the previous section. Structural designs are based on applicable US Army Corps of Engineers Design Manuals and other applicable building codes and manuals recognized by the engineering profession. No soil borings were made specifically for this study. Available soil borings in the study area and geological publications were used to the maximum extent practicable to determine foundation requirements. Geological descriptions of the subsurface are based on the publications "Distribution of Soils Bordering the Mississippi from Donaldsonville to Head of Passes, - "Tech. Report No. 3-601, June 1962, Dr. Charles R. Kolb, and "Geology of the Mississippi River Deltaic Plain - Southeastern Louisiana, "Tech. Report No. 3-483, July 1958.

PROJECT SITE EVALUATION

C.2.3. During the preliminary evaluation, 13 alternative locations along the Mississippi River were identified as diversion sites. The engineering reconnaissance analysis consisted of preliminary design of structures, channels, and associated works necessary to use the sites. The analysis determined the hydraulic efficiency of each site, identified design and relocation problems, evaluated site performance in achieving study objectives, and developed a preliminary cost estimate

for comparison of site economics. A list of the 13 sites and the preliminary evaluation and assessment to determine sites for further study is in the Plan Formulation Appendix. The interdisciplinary planning team determined that three sites warranted intermediate stage investigations after considering all factors affecting site selection.

The sites are:

Riverbend
Inner Harbor Navigation Canal Lock (IHNC)
Bonnet Carre'

C.2.4. The Riverbend and IHNC sites were subsequently eliminated because an economically feasible plan could not be developed to provide the required supplemental flows to achieve optimum salinity condition at Location #2. The design and cost of the Bonnet Carre' site is discussed in subsequent paragraphs.

DESIGN CRITERIA

C.2.5. Hydrology and hydraulic studies discussed in Section 1 determined the magnitude of supplemental water required and have shown that supplemental fresh water must be diverted to the basin during March through November in order to be effective in establishing desired salinity conditions. The Mississippi River stages corresponding to the 50 percent duration flow for the 70 percent latitude flow at Red River landing were transferred to the diversion structure location for each month of the year. Based on the expected stages and supplemental water requirements, several types of diversion structures we studied: siphons, pumps, tainter gates, and multi-cell concrete box culverts with steel vertical lift gates. Siphons are impractical because of size and head loss. Pumps are too costly. Both tainter gates and multi-cell concrete box culverts were determined to be suitable, but multi-cell

concrete box culverts were selected to be used at the diversion site because they are generally less expensive. Tainter gates must also be constructed to the full height of the flood protection levee and are more susceptible to damage.

C.2.6. The hydraulic criteria used to design the diverstion structure are submergence and velocity. The losses through the structure were computed using the Darcy equation with a friction coefficient "f" = 0.015 for the friction losses of 0.5 and 1.0 times the velocity head for the entrance and exit losses, respectively. For the maximum discharge of 30,000 cfs, the average velocity through the structure would be about 8 feet per second (fps). The 8 fps velocity was used to determine the total cross sectional area required to pass the required supplemental flows.

C.2.7. An analysis of three different size culverts was made to determine the most economical size. Three sizes of culverts were analyzed: 15' x 15', 15' x 20', and 20' x 20'. The analysis indicated that the most economic size for the proposed site was 20' x 20'.

C.2.8. The hydraulic criteria for the diversion channel are uniform flow and average velocities of approximately 3 fps for the maximum discharge of 30,000 cfs. Starting at the receiving body of water, Lake Pontchartrain, with a mean high tide of 1.6 feet NGVD and using Manning equation with a value for "n" = 0.035, several tailwater elevations were computed at the diversion structure using fixed 1V on 3H sideslope with different bottom widths and water depths. The tailwater elevations at the structures were computed by using the HEC-2 Program to route the freshwater diversion upstream.

C.2.9. The channel length was 33,800 feet and was divided in four reaches. The first reach is from Lake Pontchartrain to the existing borrow channel for a distance of 3,400 feet. The second reach utilizes

the existing borrow channel for a distance of 10,600 feet to just north of Airline Highway. The third reach of 5,700 feet is alined to avoid the Airline Highway earthern embankment from the borrow channel through the Airline Highway bridge and then parallel to the upper guide levee. The fourth reach extends from Airline Highway to the diversion structure for a distance of 14,000 feet. The optimum diversion channel size would have a cross-section with a bottom width of 400 feet, 1V on 3H sideslopes and a water depth of 25 feet.

C.2.10. Several differential heads were computed based on the tailwater and headwater obtained as indicated in the previous paragraph. This differential head is the head available to overcome the system losses. For submerged discharge the equation is:

$$H = He + Hf + Ho \qquad (1)$$

Where:

H = available head

He = entrance loss = ke $V^2/2g$

Hf = friction loss = kf $V^2/2g$

Ho = outlet loss = ko $V^2/2g$

ke = entrance loss coefficeint = 0.5

kf = friction loss coefficient = fxL/D

ko = outlet loss coefficient = 1

By substitution in equation (1), we obtain:

$$H = (0.5 + fxL/D + 1)\ V^2/_{2g} \text{ in ft} \quad (2)$$

$$V = \left(\frac{2gH}{1.5 + fxL/D}\right)^{1/2} \text{ in fps} \quad (3)$$

or $$V = C\sqrt{2gH} \quad \text{in fps} \quad (4)$$

$$\text{and } Qc = CA\sqrt{2gH} \quad \text{in cfs} \quad (5)$$

where

Qc = Discharge of one culvert box, cfs

A = cross-sectional area of culvert, sf

f = friction factor = 0.015, dimensionless

L = culvert length, ft.

D = diameter of circular section, ft

C = discharge coefficient = $\dfrac{1}{\sqrt{1.5 + fxL/D}}$

By relating the diameter D of a circular section to its hydraulic radius R, we obtain:

$$R = \frac{A}{P} = \frac{\text{area}}{\text{wetted perimeter}} = \frac{\pi D^2}{4} \times \frac{1}{\pi D} = \frac{D}{4} \text{ or } D = 4R$$

For a square section with a side B

$$R = \frac{A}{P} = \frac{B^2}{4B} = \frac{B}{4} = \text{ or } B = 4R$$

It can be seen that a diameter in a circle and a side in a square are related to the hydraulic radius of their respective cross-section in the same way, that is 4R, which means that D can be substituted by B when the section is square.

C.2.11. Based on the equations above and differential head for each month and required supplemental flows, the number of culvert boxes were determined for Locations #2 and #3. The culvert requirements are shown in table C-2-1 for Location #2.

TABLE C-2-1

CULVERT REQUIREMENT TO ACHIEVE
OPITMUM SALINITY CONDITIONS AT LOCATION #2

MONTH	DAILY DIV CFS	STG AT BC FT NGVD	CH 400' x 25 ' TW FT. NGVD	NO. OF CULVERTS		
				15'x15'	20'x20'	15'x20'
JAN	0	7.5	----	-	-	-
FEB	0	10.2	----	-	-	-
MAR	10,800	13.4	1.95	3	2	2
APR	30,000	14.8	4.31	8	4	6
MAY	16,700	13.3	2.41	4	3	3
JUN	14,600	8.8	2.22	5	3	4
JUL	3,200	4.9	1.63	2	1	1
AUG	2,600	3.0	1.62	2	1	2
SEP	2,000	2.3	1.61	2	1	2
OCT	5,500	2.4	1.69	6	3	4
NOV	3,200	2.5	1.63	3	2	2
DEC	0	3.5	----	-	-	-

FOUNDATIONS AND MATERIALS

C.2.12. Foundation sediments at the diversion site consist of Holocene Mississippi River alluvium underlain by Pleistocene deltaic material. Surface elevations in the area of the diversion structure are approximately +10 to +12 feet NGVD. As shown on Boring R-128.9-L, presented on plates C-21 and C-22, the surface material is natural levee deposits consisting of mostly fat clays to an elevation of about -5 feet NGVD. Underlying the natural levee deposits are point bar deposits consisting of silts and silty sands with clay layers interspersed. The Pleistocene surface will be encountered at elevation -120 feet NGVD.

The conditions indicate the necessity for a pressure relief system at the diversion site to control underseepage, excessive hydrostatic pressure, and to insure excavation slope stability. The use of the existing Mississippi River levee during construction of the structure and the new setback levee precludes the need of a riverside cofferdam. For analysis, the strengths used were taken from the general strength trend developed for the Reach M-121 to M-133 in the levee report "LaPlace to Destrehan Levee Enlargement." An analysis was performed to check the stability of the proposed 1V on 4H structure excavation slopes. The critical factor of safety for the dewatered stage is 1.6. The critical plane was determined to be at approximately elevation -36 at a clay/silt interface. The excavation with respect to the existing Mississippi River levee was designed assuming high water on the riverside for a factor of safety of 1.3. The factor of safety against failure of the existing Bonnet Carre' structure and the excavation is significantly greater than 1.30. After locating the excavation with respect to the existing levee, analyses were performed to design the necessary berms and to check the overall stability of the relocated Mississippi River levee and the inflow and outflow channels, inside and outside of the structure excavation. Analyses of the inflow channel assumed low water on the riverside while those of the outflow channel assumed high water on the riverside. The resulting designs are shown on plate C-23. Analyses were also performed to determine the locations of the relocated levees with respect to the channels. The Mississippi River levee transition from the existing to the relocated levee segment was checked using low water on the riverside. The location of the relocated upper guide levee with respect to the outflow channel was determined using the point bar stratigraphy in the area of the structure. The location of the upper guide levee with respect to the channel and the necessary berms was determined using the marsh clay stratigraphy that exists downstream from the structure toward Lake Pontchartrain. A factor of safety of 1.3 was used for all analyses. Distances necessary for stability were used for development of the

overall levee plan layout and for right-of-way requirements. Designs are presented on plate C-24.

C.2.13. Surface elevations toward the lakeside of the outflow channel are approximately +2 to +5 feet NGVD. Existing borings outside the project indicate a marsh stratification consisting of fat clays throughout, as shown on Borings 2, 3, 4, and 5-SCJU, and Plates C-25, C-26, C-27, and C-28. Strengths used for analysis were derived from these borings.

SITE DESIGN AND COSTS

STRUCTURE AND CHANNEL

C.2.14. The diversion structure would be reinforced concrete multi-cell concrete box culverts with steel vertical lift gates. The gates would be installed on the riverside of the culvert boxes to prevent pressuring the box culverts beneath the levee during high river stages. The culverts and gates would be capable of withstanding pressure due to high Lake Pontchartrain stages. The structure would withstand stages in the lake that may reach between 8 to 10 feet during a hurricane and low Mississippi River stages. An electric motor and gear mounted on pedestals would raise the vertical lift gates on two tandem vertical threaded steel stems per gate. The diversion structure would have four 20' x 20' cells, 455 feet long with an invert elevation of -21 feet NGVD. On the lake side of the structure, riprap would be placed in t' diversion channel for a distance of 500 feet to prevent channel scouring. Soil borings taken on the Mississippi River levee centerline in the vicinity of the proposed structure shows a point bar stratigraphy consisting of predominantly silty sands. Also, approximately 35 feet of overburden will be removed before the structure is founded. Based on these considerations and the scope of this report, it is anticipated that the bearing capacity of the founding soils will be sufficient

TABLE C-2-9

SUMMARY OF PERTINENT DATA AND FIRST COSTS FOR LAND AND DAMAGES

FRENIER BEACH

ESTIMATE OF COSTS

		Acres	Unit Value	Total Value
(a) Lands & Damages				
Fee				
Dryland		2	$8,100	$16,200
Improvements				0
Severance Damage				0
Total				$16,200
Contingencies 25% (R)				4,000
(b) Acquisition Costs (Estimated 1 tract)				
Non-Federal	1 @ $1,400 per tract (R)			1,000
Federal	1 @ 700 per tract (R)			1,000
(c) PL-91-646				0
(d) Total Estimated Real Estate Cost				$22,200

TABLE C-2-8

REVISED SUMMARY OF PERTINENT DATA
AND FIRST COST FOR LANDS AND DAMAGES

BONNET CARRE' SITE

ESTIMATE OF COSTS

		Acres	Unit Value	Total Value
(a)	Lands & Damages			
	Fee (Structure Site) Potential Residential	4.8	$15,000	$ 72,000
	Perpetual Levee R/W (Miss. River)			
	Residential	3.0	20,000	60,000
	Potential Residential	0.7	15,000	10,500
	Perpetual Levee R/W (Upper Guide)			
	Residential	18.2	20,000	364,000
	Potential Residential	8.0	15,000	120,000
	Perpetual Channel R/W			
	Residential	10.5	20,000	210,000
	Potential Residential	26.3	15,000	394,500
	Perpetual Road R/W			
	Residential	1.9	20,000	38,000
	Potential Residential	3.8	15,000	57,000
	Improvements			991,000
	Severance Damage			25,000
	Total (R)			$2,342,000
	Contingencies 25% (R)			586,000
(b)	Acquisition Costs (Estimated 83 tracts)			
	Non-Federal	83 @ $1,400 per tract		116,000
	Federal	83 @ 700 per tract		58,000
(c)	PL-91-646			925,000
(d)	Total Estimated Real Estate Cost			$4,027,000

TABLE C-2-7

SUMMARY OF PERTINENT DATA AND FIRST COSTS FOR LANDS AND DAMAGES

BONNET CARRE' SITE

ESTIMATE OF COSTS			
(a) LANDS & DAMAGES	ACRES	UNIT VALUE	TOTAL VALUE
Fee (Structure Site)			
Potential Residential	4.8	$15,000	$ 72,000
Perpetual Levee R/W (Miss. River)			
Residential	3.0	20,000	60,000
Potential Residential	0.7	15,000	10,500
Perpetual Levee R/W (Upper Guide)			
Residential	2.2	20,000	44,000
Potential Residential	8.0	15,000	120,000
Perpetual Channel R/W			
Residential	10.5	20,000	210,000
Potential Residential	26.3	15,000	394,500
Perpetual Road R/W			
Residential	1.9	20,000	38,000
Potential Residential	3.8	15,000	57,000
Improvements			489,000
Serverance Damage			25,000
TOTAL (R)			$1,520,000
Contingencies 25% (R)			380,000
(b) ACQUISITION COSTS (Estimated 36 tracts)			
Non-Federal	36 @ $1,400 per tract		50,000
Federal	36 @ 700 per tract		25,000
(c) PL-91-646			400,000
(d) TOTAL ESTIMATED REAL ESTATE COST			$2,375,000

TABLE C-2-6 (CONTINUED)

SUMMARY OF FIRST COST FOR RELOCATIONS

BONNET CARRE' SITE

COST ACCOUNT NO	ITEM	QUANTITY	UNIT	UNIT PRICE	COST
	Subtotal - Relocations				6,589,440
	Contingencies (±25%)				1,646,560
	Subtotal				$8,236,000
30	E&D (±6%)				494,000
31	S&A (±6%)				494,000
	TOTAL				$9,224,000

TABLE C-2-6

SUMMARY OF FIRST COST FOR RELOCATIONS

BONNET CARRE' SITE

COST ACCOUNT NO	ITEM	QUANTITY	UNIT	UNIT PRICE	COST
02	Relocations				
.1	Roads				
	LA Hwy 628				
	Remove Exist Road				
	Pavement	3,500	LF	27.00	$ 94,500
	Embankment	15,560	CY	2.00	31,120
	Reinstall Road				
	Pavement	3,600	LF	165.00	594,000
	Embankment	16,000	CY	5.50	88,000
	Timber Bridge	LS	LS	-	681,000
	Shell Road				
	Road Embankment	45,840	CY	5.50	252,120
	Shell	1,200	CY	17.00	20,400
	Subtotal - Roads				1,761,140
.4	Railroads				
	L&A Railroad				
	Illinois Central Railroad				
	Remove Existing Track	1,800	LF	11.00	19,800
	Reinstall Track	1,800	LF	55.00	99,000
	Install Temp Track	3,000	LF	165.00	495,000
	Remove Temp Track	3,000	LF	11.00	33,000
	Steel Deck Bridge	1,800	LF	1,700.00	3,060,000
	Subtotal - Railroads				3,706,800
.7	Utilities				
	DOW Chem. 16" gas	600	LF	325.00	195,000
	McAlester Fuel Co 20" oil	600	LF	365.00	219,000
	Southern Gas & Fuel 16" gas	600	LF	325.00	195,000
	Southern Gas & Fuel 18" gas	600	LF	350.00	210,000
	United Gas 4" gas	700	LF	80.00	56,000
	Norco Gas & Fuel 2" gas	3,500	LF	12.00	42,000
	St. Charles Parish 6" watermain	3,500	LF	13.00	45,500
	LP&L 13.8 KV powerline	3,500	LF	21.00	73,500
	LP&L 115 KV powerline	LS	LS	-	40,000
	SCB 200 pr aerial cable	3,500	LF	13.00	45,500
	Subtotal - Utilities				1,121,500

openings and replacement of a shell-surfaced road near the Bonnet Carre' structure are required to maintain access within the spillway. The railroad trestles require relocation because the timber piers that support the tracks will be undermined by the flow through the diversion channel. The pipeline and powerline relocations are required by the construction of the diversion channel.

C.2.23. The existing Louisiana Highway 628 parallels the upper guide levee. Where the upper guide levee intersects the Mississippi River, the highway turns and parallels the Mississippi River levee. With the freshwater diversion structure in place, the upper guide levee and the Mississippi River levee would be realined and Louisiana Highway 628 would be relocated adjacent to these realined levees. The access road which provides access on the landside of the structure through the floodway would be realined over the Mississippi River levee setback over the diversion structure.

C.2.24. All pipelines would be built to the capacities and equivalent engineering criteria of the existing facilities. Highway and roads would be replaced to current Louisiana highway standards. Relocated railroads would be built to the same load limitation and engineering criteria as the existing facility. Pertinent information on the proposed relocations is displayed in table C-2-6.

REAL ESTATE

C.2.25. Lands required for the Bonnet Carre' plan include fee acquisition of lands required for the structure, recreation sites, and road relocation, and perpetual easements on lands required for levees and inflow and outflow channels located outside of the Bonnet Carre' Floodway. Estimated first costs for lands and damages are shown in tables C-2-7 thru C-2-13.

TABLE C-2-5

SUMMARY OF FIRST COST FOR RECREATION FACILITIES

BONNET CARRE'

COST ACCOUNT NO	ITEM	QUANTITY	UNIT	UNIT PRICE	COST
14	2-Lane Boat Ramp	6	LS	$60,000	$360,000
	1/2 Acre Parking for 30 vehicles	6	LS	11,000	66,000
	Trash Receptacles	30	LS	150	4,500
	Picnic Tables	30	LS	550	16,500
	Land Preparation	12	LS	2,000	24,000
	Subtotal				471,000
	Contingencies (±25%)				117,810
	Subtotal				$588,810
	E&D (±10%)				58,880
	S&A (±9%)				52,990
	TOTAL				$700,680
	TOTAL ROUNDED				$700,700

TABLE C-2-4

SUMMARY OF FIRST COST FOR LEVEES

BONNET CARRE' SITE

COST ACCOUNT NO	ITEM	QUANTITY	UNIT	UNIT PRICE	COST
11	Levees				
	Mississippi River Levee				
	Clearing and Grubbing	LS	LS	-	$ 3,000
	Embankment	83,500	CY	2.00	167,000
	Fertilizing & Seeding	3	Acre	1,200.00	3,600
	Shell Surfacing	260	CY	20.00	5,200
	Concrete Slope Paving	890	SY	110.00	97,900
	Environment Protection	LS	LS	-	1,000
	Subtotal				277,700
	Upper Guide Levee				
	Clearing & Grubbing	LS	LS	-	5,000
	Embankment	94,500	CY	2.00	189,000
	Fertilizing & Seeding	9	Acre	1,200.00	10,800
	Shell Surfacing	1,400	CY	20.00	28,000
	Environment Protection	LS	LS	-	1,000
	Subtotal				233,800
	Subtotal Levees				511,500
	Contingencies (±25%)				127,500
	Subtotal				$639,000
30	E&D (±9%)				58,000
31	S&A (±10%)				64,000
	TOTAL				$761,000

on the protected side and would tie into the MRL. Approximately 1,250 feet of the MRL would be constructed over the diversion structure which is located behind the existing MRL. The existing MRL would serve as a cofferdam during construction of the diversion structure. The first costs of the realined upper guide levee and MRL are shown on table C-2-4. Levee cross-sections are shown on plates C-23 and C-24.

RECREATION FACILITIES

C.2.21. Recreation facilities would be constructed at six locations in the study area. They are: the lake end of the borrow channel within the Bonnet Carre' Floodway, Frenier Beach, the Rigolets, and Point Aux Herbes in Louisiana, and Cedar Point and Wolf River in Mississippi (plate G-1, Appendix G.) Approximately 2 acres per site would be developed consisting of a two-lane ramp 24 feet wide, five picnic tables, five trash cans, courtesy pier, and parking for 30 vehicles. The first cost of recreation facilities is shown in table C-2-5.

RELOCATIONS

C.2.22. The determination of the relocations required for the Bonnet Carre' diversion plan was based on available office information and field studies. At the site, Louisiana State Route 628, a two-lane asphalt surfaced roadway, parallels both the upper guide levee and the MRL would be impacted by the construction. A 13.8 KV powerline, a 200 pair telephone cable, a 2-inch gas main, and 6-inch water main parallel Highway 628 would be relocated concurrently with the road relocation. The remaining relocations are located within the Bonnet Carre' Floodway. These relocations consist of construction of a timber bridge near Airline Highway, construction of three railroad trestles, replacement of a shell-surfaced roadway, relocation of six oil and gas pipelines, and relocation of a 115 KV powerline. Construction of a timber bridge near Airline Highway capable of withstanding spillway

TABLE C-2-3

SUMMARY OF FIRST COST FOR CHANNELS

BONNET CARRE' SITE

COST ACCOUNT NO	ITEM	QUANTITY	UNIT	UNIT PRICE	COST
09	Channel and Canals				
	Mobilization and Demobilization	LS	LS	-	$ 250,000
	Bucket Dredging	11,300,000	CY	1.00	11,300,000
	Sediment Trap	665,000	CY	1.00	665,000
	Riprap (Airline Hwy Bridge) 24"	17,000	Ton	18.00	306,000
	Subtotal				12,521,000
	Contingencies (±25%)				3,130,000
	Subtotal				$15,651,000
30	E&D (±6%)				939,000
31	S&A (±6%)				939,000
	TOTAL				$17,529,000

C.2.19. The diversion channel through the floodway would sever access roads used by sand haulers. A timber bridge capable of withstanding spillway openings is provided across the diversion channel just above the Illinois Central Gulf railroad to give sand haulers continued access in and out of the floodway to the west.

LEVEE

C.2.20. About 3,035 feet of upper guide levee would be realined to inclose the diversion structure and channel within the floodway. The realined levee would provide flood protection to adjacent residents during Bonnet Carre' openings. The upper guide levee would be 12 to 16 feet high with sideslopes of 1V on 5.5H on the floodside and IV on 3.5H

Airline Highway. The outflow channel takes a more northly direction for a distance of 5,700 feet where it enters the existing borrow channel. The existing borrow channel has sufficient capacity to convey the design flow and is used for a distance of 10,600 feet. From the end of the existing borrow channel the diversion channel is alined in a more northeasterly direction to avoid the upper guide levee since the diversion channel begins to widen as it enters Lake Pontchartrain. This part of the channel that extends into the lake is 3,400 feet. The outflow channel is designed to contain all diverted flows within the banks. Typical cross-sections of the inflow and outflow channel and borrow channel are shown on plate C-30. A profile of the channel is shown on plate C-31.

C.2.17. The channel would be excavated by bucket dragline in the floodway and bucket dragline on barges in open areas in Lake Pontchartrain. Excavated material in the floodway would be placed adjacent to the diversion channel 3 to 4 feet high to be removed by sand haulers that currently remove material from the floodway. Excavation of the channel to design cross section would take an estimated 24 months. This estimate is based on using five draglines excavating 10,000 cubic yards per day. Mobilization, demobilization, and clearing would take an estimated 60 days. Riprap would be placed in the channel where it intersects the Airline Highway bridge to protect bridge trestles.

C.2.18. The sedimentation trap would be placed 3,500 feet downstream of the diversion structure. The top of the trap would be at elevation -21.0. The dimensions of the trap would be 15 feet deep, 1,450 feet long and 780 feet wide at elevation -36.0 with sideslopes 1V on 3H from elevation - 36.0 to elevation -21.0. The top width of the channel is 1,020 feet at elevation 4.0. Typical cross-section of the trap is shown on plate C-32. The summary of first cost for the channel and sediment trap is shown in table C-2-3. The design of the sediment trap side slopes will be finalized in the advance engineering design stage.

TABLE C-2-2 (CONTINUED)

SUMMARY OF FIRST COST FOR DIVERSION STRUCTURE

BONNET CARRE' SITE

COST ACCOUNT NO	ITEM	QUANTITY	UNIT	UNIT PRICE	COST
	Environmental Protection	LS	LS		20,000
	Dewatering System	LS	LS	-	4,300,000
	Gate Machinery	4	EA	60,000.00	240,000
	Subtotal				13,452,257
	Contingency (±25%)				3,363,064
	Subtotal				16,815,321
30	E&D (±12%)				2,017,800
31	S&A (±10%)				1,681,500
	TOTAL				$20,514,621
	TOTAL ROUNDED				$20,515,000

TABLE C-2-2

SUMMARY OF FIRST COST FOR DIVERSION STRUCTURE

BONNET CARRE' SITE

COST ACCOUNT NO	ITEM	QUANTITY	UNIT	UNIT PRICE	COST
15	Diversion Structure				
	Mobilization and Demobilization	LS	LS	-	$ 200,000
	Excavation				
	Land Based	362,000	CY	2.50	905,000
	Dredged	578,000	CY	1.00	578,000
	Reusable Backfill	157,000	CY	3.00	471,000
	Culvert Concrete	11,100	CY	300.00	3,330,000
	Culvert Reinf.	1,900,000	LBS	0.45	855,000
	Stabilization Slab	700	CY	100.00	70,000
	Prestressed Double Tee Walkway Deck	220	LF	65.00	14,300
	Walkway Footing and Column Concrete	20	CY	350.00	7,000
	Structural Steel Bulkhead	25,000	LBS	2.00	50,000
	Retaining Walls				
	Concrete				
	Base Slab	800	CY	200.00	160,000
	Wall Stem	480	CY	300.00	144,000
	Reinforcement				
	Base Slab	63,052	LBS	0.45	28,373
	Wall Stem	69,736	LBS	0.45	31,381
	Gate Support Frame				
	Concrete				
	Beam	76	CY	200.00	15,200
	Columns	103	CY	350.00	36,050
	Reinforcement				
	Beam	12,537	LBS	0.45	5,642
	Columns	27,292	LBS	0.45	12,281
	Structural Steel Gate	144,000	LBS	1.75	252,000
	Embedded Materials	68,740	LBS	3.00	206,220
	Misc. Metals	30,500	LBS	2.50	76,250
	Riprap (24", 36" 48")	39,970	Ton	18.00	719,460
	Riprap (60")	13,770	Ton	20.00	275,400
	Riprap (18")	24,321	Ton	14.00	340,500
	Sheetpile	8,400	SF	13.00	109,200
	Subtotal				8,892,257

to support the structure without piles. During the GDM phase when site-specific borings are made, a final determination as to the need for pile will be made.

C.2.15. The estimated construction time for the diversion structure is 2 years. The diversion structure would be constructed approximately 550 feet behind the centerline of the existing Mississippi River levee (MRL) to take advantage of the levee as a cofferdam. The MRL used as a cofferdam would be degraded and a new MRL would be constructed over the diversion structure. Temporary by-passes for railroads and roads would be provided during construction to accommodate traffic. The railroads and roads would be replaced to the appropriate standard and criteria. A summary of estimated first cost for the diversion structure is shown in table C-2-2. The diversion structure and channel are shown on plate C-29.

C.2.16. Associated works of the diversion structure include inflow and outflow channels, sedimentation trap, access bridge, realined levee, and recreation facilities. The inflow channel would be about 950 feet long with a bottom width of 400 feet, 1V on 3H sideslopes and a water depth of 25 feet. Both banks of inflow channel would require 18 inches of riprap from the intersection of the channel with the Mississippi River to the diversion structure. The total distance of the outflow channel is 33,800 feet. The outflow channel would have the same cross-sectional area as the inflow channel. At the lake end the channel bottom width is increased to 590 feet and then 760 feet over a channel length of 1,000 and 336 feet. The channel depth is decreased to 10 feet and then to 2 feet over the same length. This is to avoid relocation of Interstate 10. The outflow channel would be alined in a northeasterly direction from the diversion structure for a distance of 3,500 feet. The outflow channel is then alined parallel to the upper guide levee for a distance of 5,100 feet. To avoid the Airline Highway (US 61) earthen embankment the channel is alined in a northeasterly direction for 5,500 feet above

TABLE C-2-10

SUMMARY OF PERTINENT DATA AND FIRST COSTS FOR LAND AND DAMAGES

POINTE AUX HERBES

ESTIMATE OF COSTS

		Acres	Unit Value	Total Value
(a) Lands & Damages				
Fee Marshland		2	$250	$ 500
Improvements				0
Severance Damage				0
Total				$1,000
Contingencies 25% (R)				1,000
(b) Acquisition Costs (Estimated 1 tract)				
Non-Federal	1 @ $1,400 per tract (R)			1,000
Federal	1 @ 700 per tract (R)			1,000
(c) PL-91-646				0
(d) Total Estimated Real Estate Cost				$4,000

TABLE C-2-11

SUMMARY OF PERTINENT DATA AND FIRST COSTS FOR LAND AND DAMAGES

THE RIGOLETS

ESTIMATE OF COSTS

		Acres	Unit Value	Total Value
(a) Lands & Damages				
Fee				
Marsh		2	$1,400	$ 2,800
Improvements				0
Severance Damage				0
Total				$ 3,000
Contingencies 25% (R)				1,000
(b) Acquisition Costs (Estimated 1 tract)				
Non-Federal	1 @ $1,400 per tract (R)			1,000
Federal	1 @ 700 per tract (R)			1,000
(c) PL-91-646				0
(d) Total Estimated Real Estate Cost				$ 6,000

TABLE C-2-12

SUMMARY OF PERTINENT DATA AND FIRST COSTS FOR LAND AND DAMAGES

CEDAR POINT

ESTIMATE OF COSTS

(a) Lands & Damages	Acres	Unit Value	Total Value
Fee Marshland	2	$500	$1,000
Improvements			0
Severance Damage			0
Total			$1,000
Contingencies 25% (R)			1,000
(b) Acquisition Costs (Estimated 1 tract)			
Non-Federal	2 @ $1,400 per tract (R)		3,000
Federal	2 @ 700 per tract (R)		1,000
(c) PL-91-646			0
(d) Total Estimated Real Estate Cost			$6,000

TABLE C-2-13

SUMMARY OF PERTINENT DATA AND FIRST COSTS FOR LAND AND DAMAGES

WOLF RIVER

ESTIMATE OF COSTS

		Acres	Unit Value	Total Value
(a) Lands & Damages				
Fee Marshland		2	$500	$1,000
Improvements				0
Severance Damage				0
Total				$1,000
Contingencies 25% (R)				1,000
(b) Acquisition Costs (Estimated 1 tract)				
Non-Federal	1 @ $1,400 per tract (R)			1,000
Federal	1 @ 700 per tract (R)			1,000
(c) PL-91-646				0
(d) Total Estimated Real Estate Cost				$4,000

[illegible] would require re- [illegible] the adverse [illegible] plan includes the [illegible] two [illegible] trailers, and [illegible].

OPERATION AND MAINTENANCE

C.2.27. Local interests would operate and maintain the diversion structures. Estimates of costs for operation and maintenance are based on the assumption that the diversion structure would operate from March through November and would divert water on an average of every other year. The diversion structure would be capable of passing the maximum design flow of 30,000 cfs during a drought with a recurrence interval of once every 2 years. The operation cost of the structure is estimated as $500 per year. This is for an operator to open and close the structure. Routine maintenance costs are estimated at $200 per year and include but are not limited to ground maintenance, greasing, painting, and removing debris at the structure. Major maintenance is estimated at $250,000 every 15 years and includes dewatering the structure to replace valves, painting and repairing machinery, electrical systems, and handrails. Annual maintenance costs for the dredging inflow channel and sediment trap are $583,000. A portable dredge would have to be transported to the sediment trap by truck. Access is not possible through the outflow channel due to obstructions by Interstate 10, railroad trestles, and Airline Highway bridge. Maintenance of the outflow channel and sediment trap would be required as a result of Bonnet Carre' Spillway openings. The Spillway has been opened seven times in the last 50 years. A similar frequency is expected during the freshwater diversion project life. Maintenance of the channel and trap as a result of spillway openings would be a non-Federal responsibility and the costs are included in the operation and maintenance costs of the channel. After water is diverted through the spillway, the

estuarine water bodies are sometimes overfreshened for short periods of time. Beneficial effects are often felt. It is estimated that 740,000 cubic yards of material is to be removed after each opening. Operation and maintenance cost for the recreation sites is estimated at $14,000. This cost is based on 2 percent of the first cost for the recreation facilities excluding land and damages.

C.2.28. Existing salinity and discharge gaging stations would be used to the maximum extent practicable for hydrologic monitoring. Data from nine U.S. Army Corps of Engineers and five U.S. Geological Survey stations will be used in determining structure operation. These stations are listed in table C-2-14 and shown on plate K-2, Appendix K. Two recording staff gages, one riverside and one landside of the structure would be added to the existing complement. Initially, discharge will be measured monthly to establish a relationship over the entire operating range. Thereafter, discharge will be measured at a minimum of three weekly basis and would consist of transects in Lake Pontchartrain, Lake Borgne, Biloxi Marsh, and the western Mississippi Sound. These data would be used to evaluate and refine monthly diversions. The average annual and maintenance costs for hydrologic monitoring is $123,000. Operation and Maintenance costs are for personnel and equipment to collect and analyze the data, and for analyses of the samples taken and interpretation of the analyses.

RECOMMENDED PLAN

C.2.29. The summary of the total first cost of the Bonnet Carre' plan is shown in table C-2-15. The Bonnet Carre' plan is the recommended plan and a cost sharing arrangement of 75 and 25 percent, respectively, between the Federal government and the non-Federal interests for the

TABLE C-14

SALINITY AND DISCHARGE GAGING STATIONS

U.S. GEOLOGICAL SURVEY
RECORDING GAGES

Amite near Denham Springs, La.
Natalbany River at Baptist, La.
Tickfaw River at Holden, La.
Tangipahoa River at Robert, La.
Tchefuncta River near Folsom, La.
Pearl River near Bogalusa, La.

U.S. ARMY CORPS OF ENGINEERS
RECORDING GAGES

Lake Pontchartrain at West End
Lake Pontchartrain at New Orleans
Lake Pontchartrain at Mandeville
Lake Borgne at Rigolets
Chef Menteur Pass near Lake Borgne
Rigolets near Lake Pontchartrain
Lake Pontchartrain near South Shore
Lake Pontchartrain at Frenier
Inner Harbor Navigation Canal near Seabrook Bridge

diversion structure, channel, and associated works within the Floodway is recommended. Recreation facilities would be cost-shared on a 50-50 basis. The Federal cost is $43,175,000 and the non-Federal cost is $14,639,000. The average annual operation and maintenance cost is $822,000 and will be entirely borne by the non-Federal interests.

TABLE C-2-15

SUMMARY OF FIRST COST FOR FRESHWATER DIVERSION

BONNET CARRE' SITE

COST ACCOUNT NO	ITEM	COST (INCLUDES CONTINGENCIES)
01	Lands and Damages	$ 2,364,200
	Acquisition Cost	186,000
	PL 91-646	925,000
	Contingencies	594,000
	Subtotal	$ 4,069,200
02	Relocations	
	.1 Roads	$ 2,201,000
	.4 Railroads	4,634,000
	.7 Utilities	$ 1,401,000
	Subtotal	$8,236,000
09	Channel and Canals	$15,651,000
11	Levees	$639,000
14	Recreation Facilities (6 sites)	700,700
15	Diversion Structure	$16,815,000
	Subtotal	$46,110,900
30	E&D	$ 3,508,800
31	S&A	$ 3,178,500
	Subtotal Cost	$52,798,200
	Monitoring Program	5,016,000
	TOTAL COST	$57,814,200
	TOTAL ROUNDED	$57,814,000

SECTION 3. LITERATURE CITED

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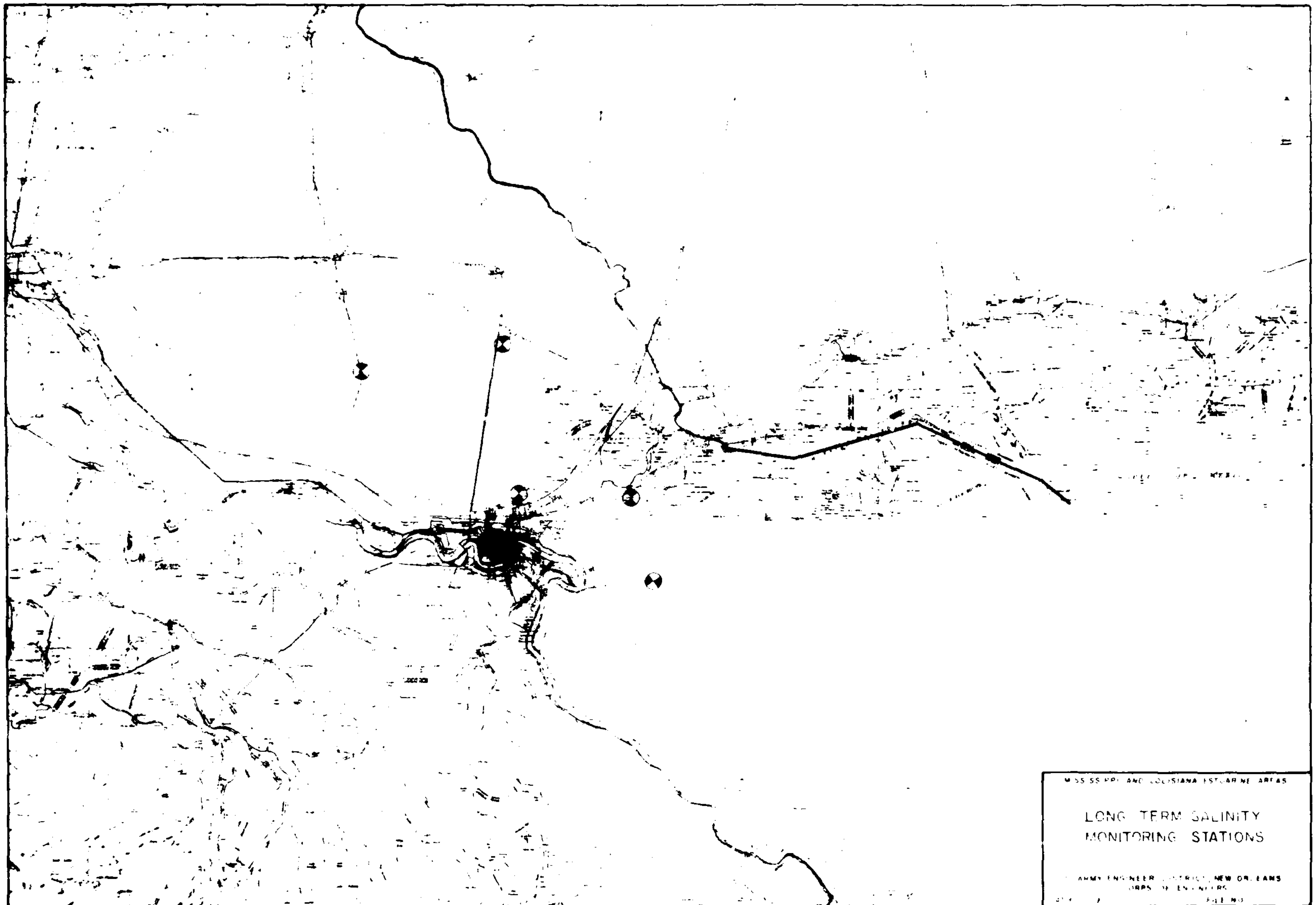
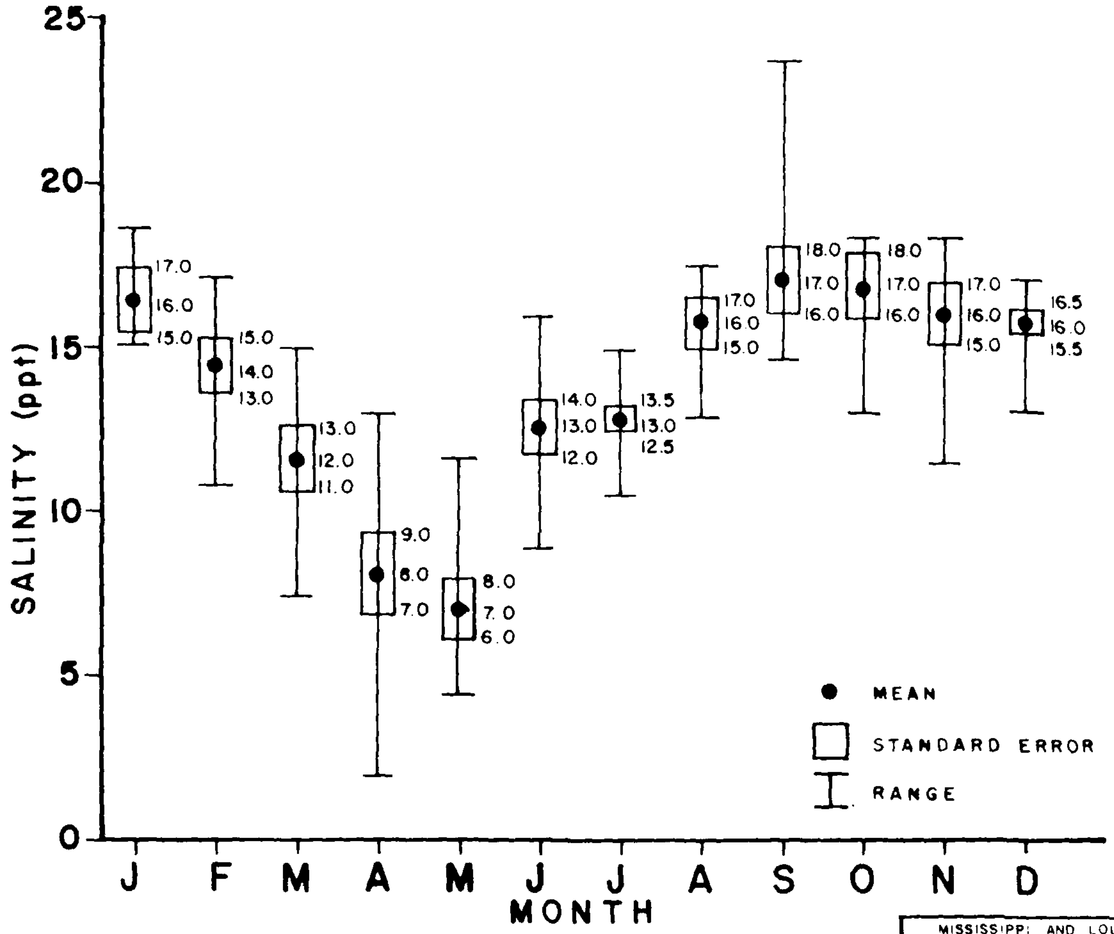

MISSISSIPPI AND LOUISIANA ESTUARINE AREAS
LONG TERM SALINITY
MONITORING STATIONS
ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

PLATE C-1



MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

OPTIMUM SALINITY REGIME

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

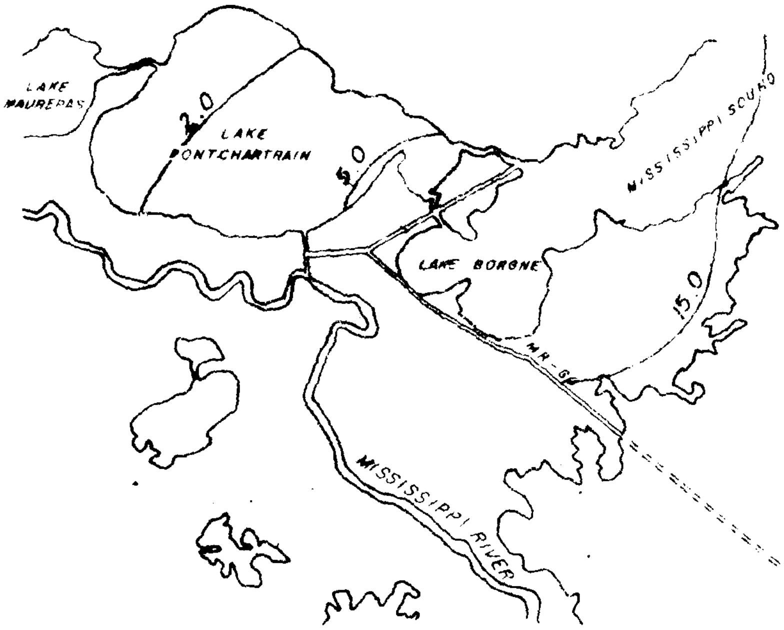
APRIL 1984 FILE NO.

PLATE C-2

PLATE C-2


NEW ORLEANS
LOCATION NO 1
LOCATION NO 2
LOCATION NO 3
SCALE OF MILES
ESTUARINE AREAS
ESTABLISH
THE OPTIMUM SALINITY REGIME
ENGINEERS
APRIL 1984
FILE NO
PLATE

JAN.



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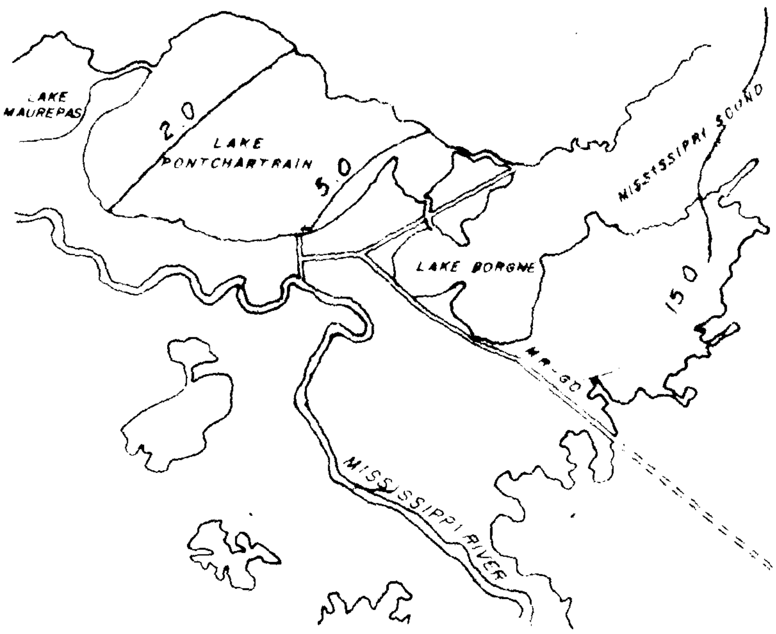


MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

MEAN MONTHLY

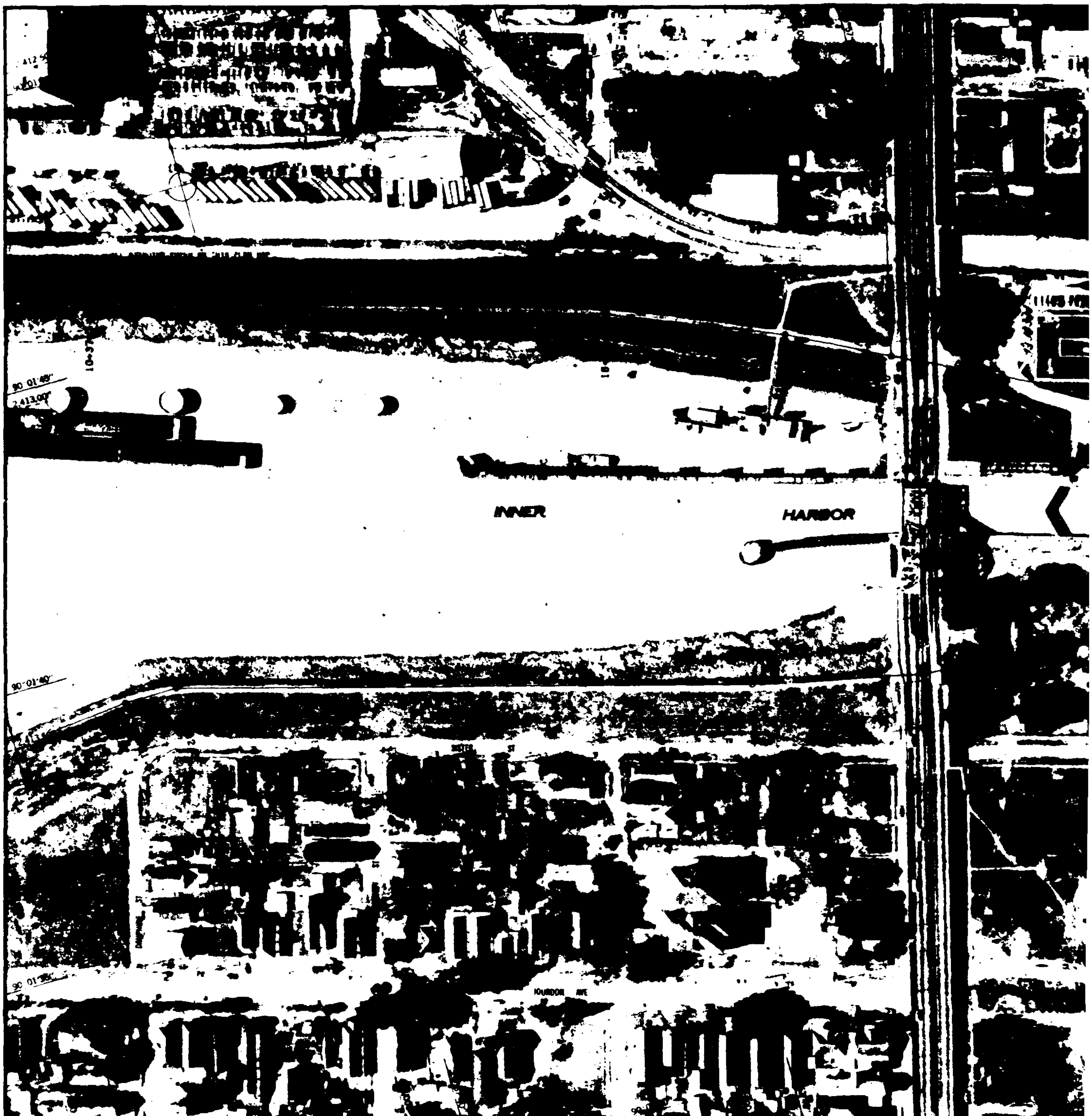
WITHOUT PROJECT

SALINITY ISOHALINES

US ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

PLATE C-4



SCALE IN FEET

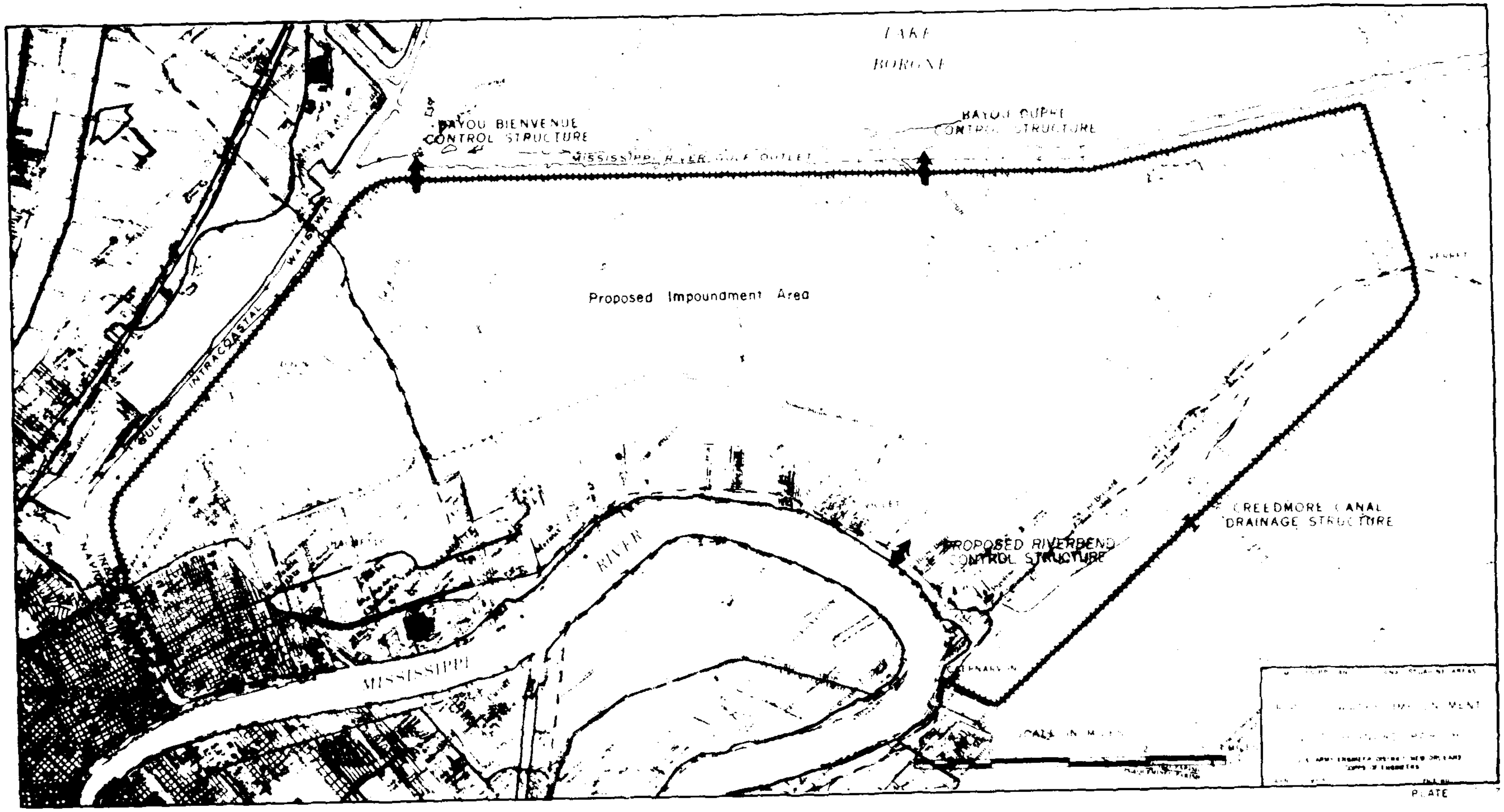
100 0 100 200 300

NOTES.

INSIDE THE PLAN AREA POLYCONIC PROJECTION 1927 NORTH AMERICAN DATUM IS SHOWN BY SOLID TICKS AND LAMBERT CONFORMAL CONIC PROJECTION IS SHOWN BY DASHED TICKS

PREPARED FROM AERIAL PHOTOS FLOWN JANUARY 1978

1 2



LAKE
BORGNE
BAYOU BIENVENUE
CONTROL STRUCTURE
BAYOU DUPRE
CONTROL STRUCTURE
Proposed Impoundment Area
GULF INTRACOASTAL WATERWAY
MISSISSIPPI RIVER
PROPOSED RIVERBEND
CONTROL STRUCTURE
CREEDMORE CANAL
DRAINAGE STRUCTURE
PLATE

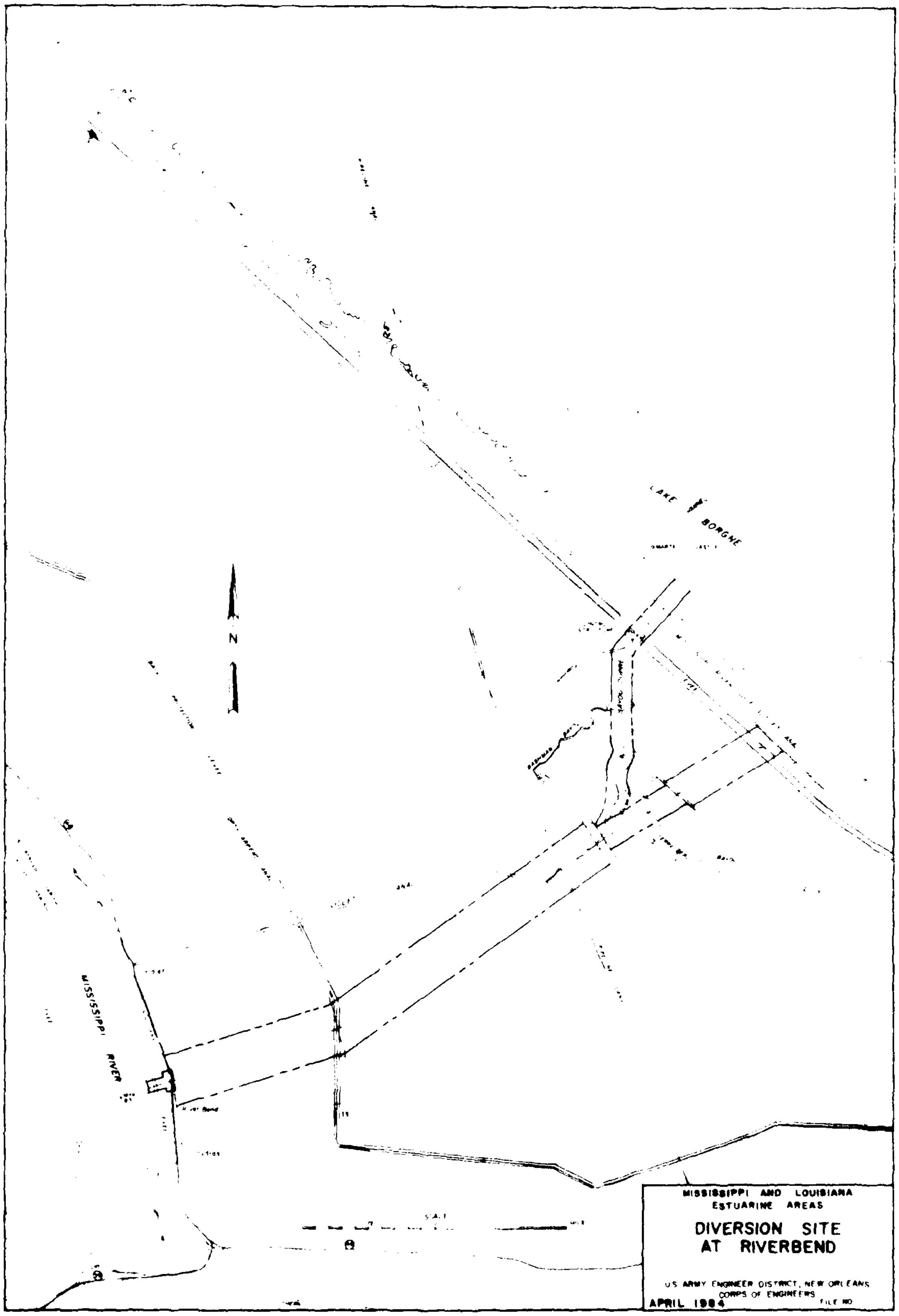
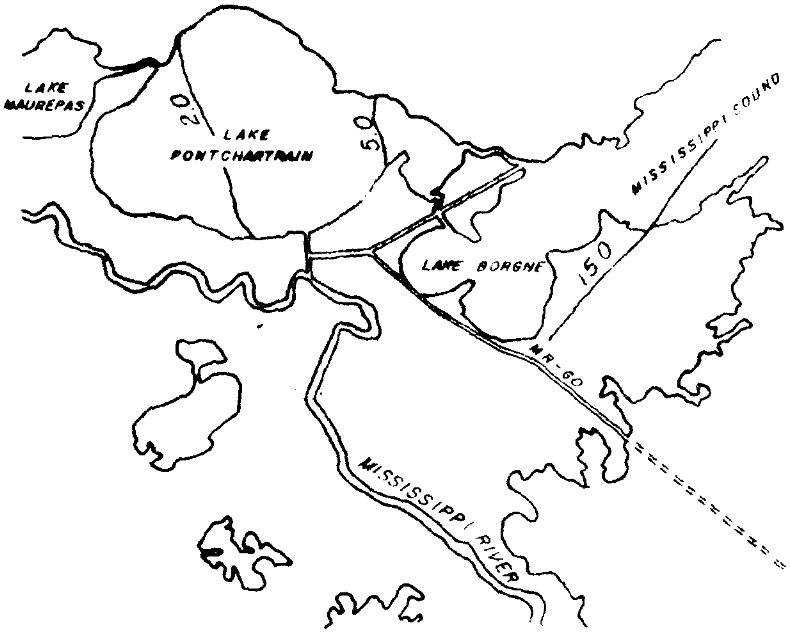

LAKE BORGNE
N
MISSISSIPPI RIVER
MISSISSIPPI AND LOUISIANA
ESTUARINE AREAS
DIVERSION SITE
AT RIVERBEND
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
APRIL 1984

PLATE C-16

NOV



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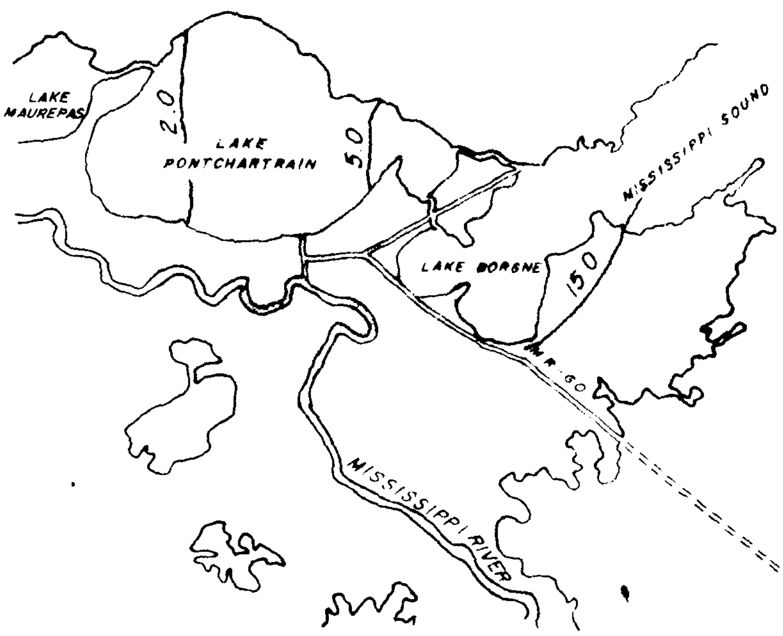


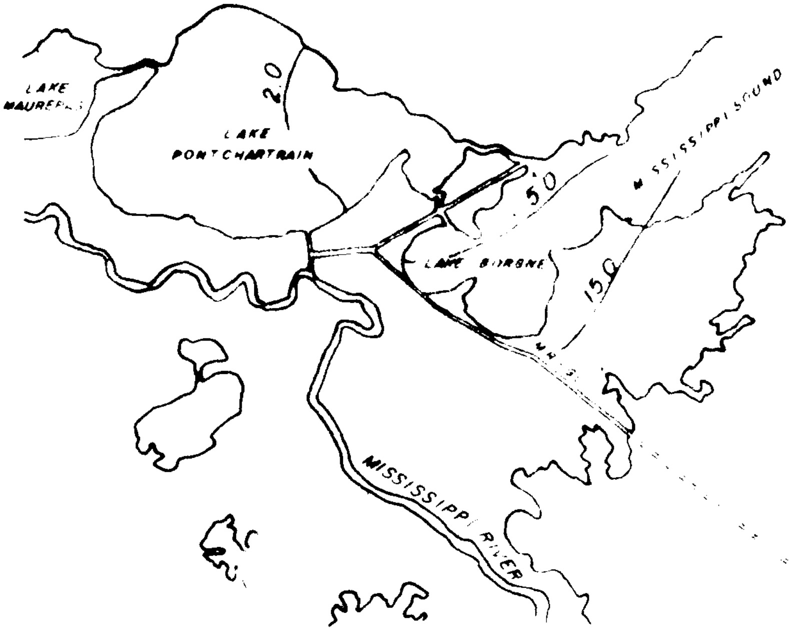
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

MEAN MONTHLY
WITH PROJECT
SALINITY ISOHALINES

US ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

PLATE C-15



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MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

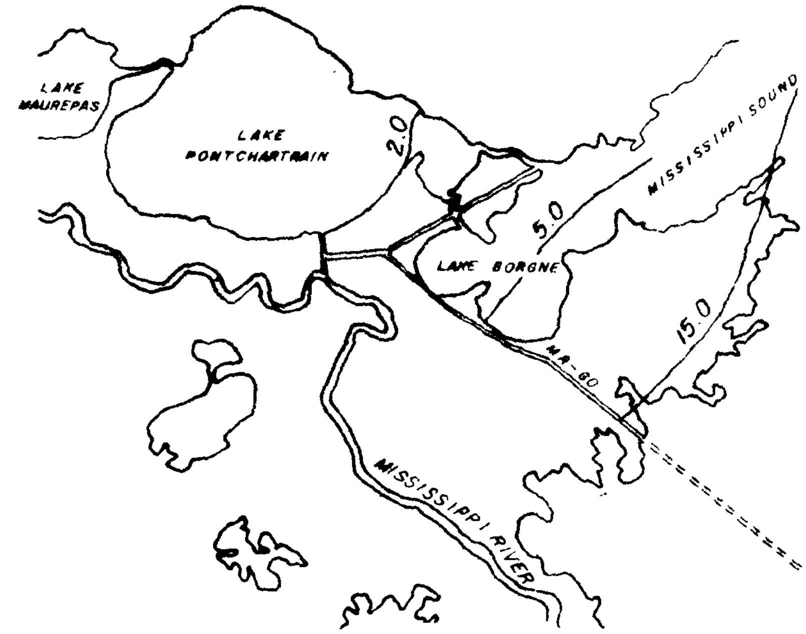
MEAN MONTHLY WITH PROJECT SALINITY ISOHALINES

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

PLATE C-14

JUL



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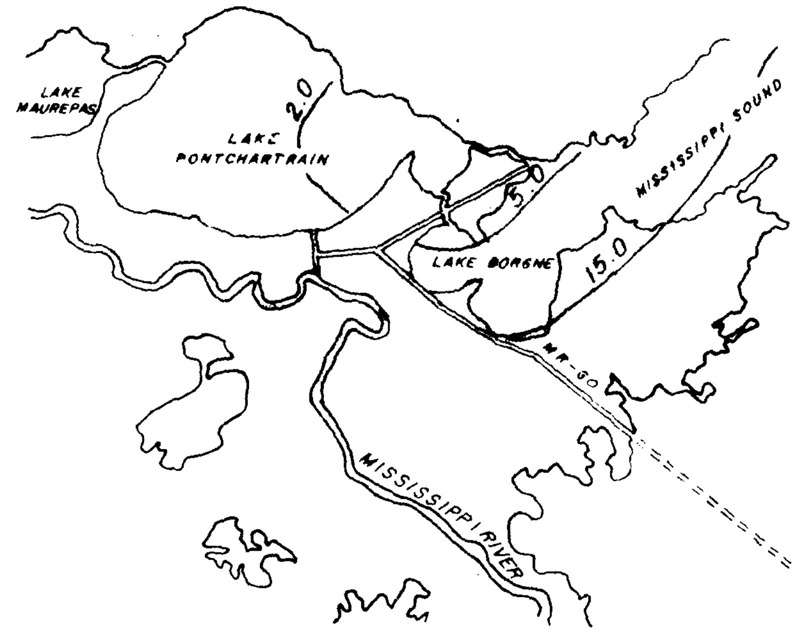


MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

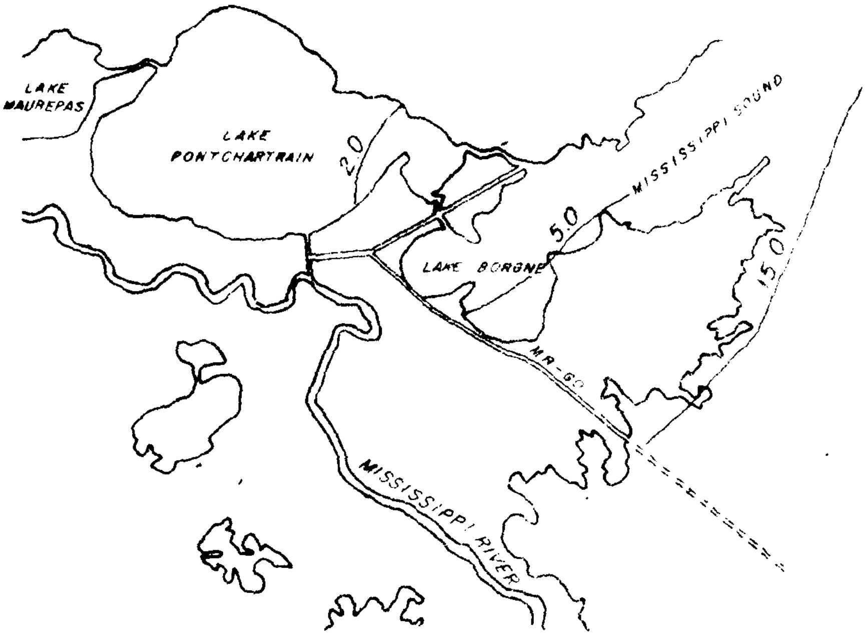
MEAN MONTHLY
WITH PROJECT
SALINITY ISOHALINES

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

PLATE C-13

MAY



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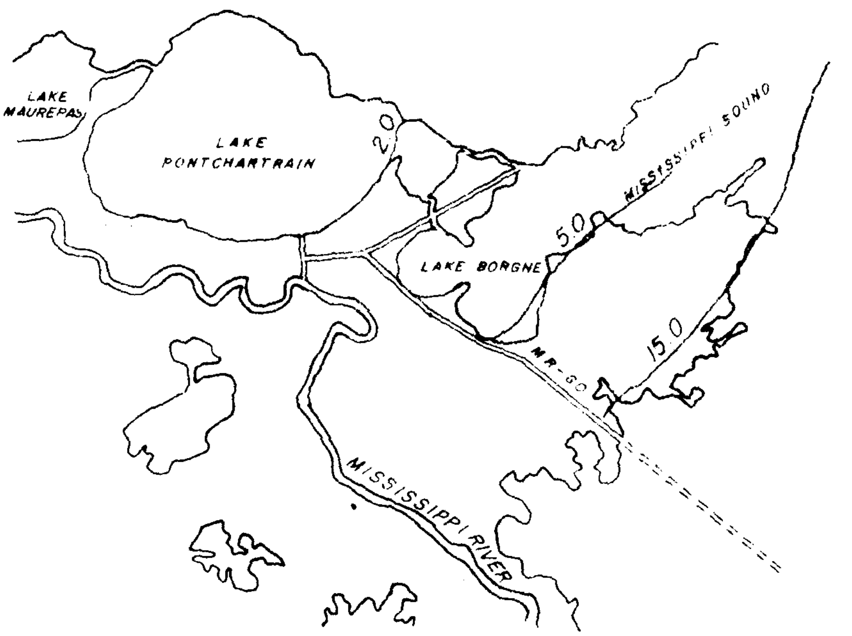


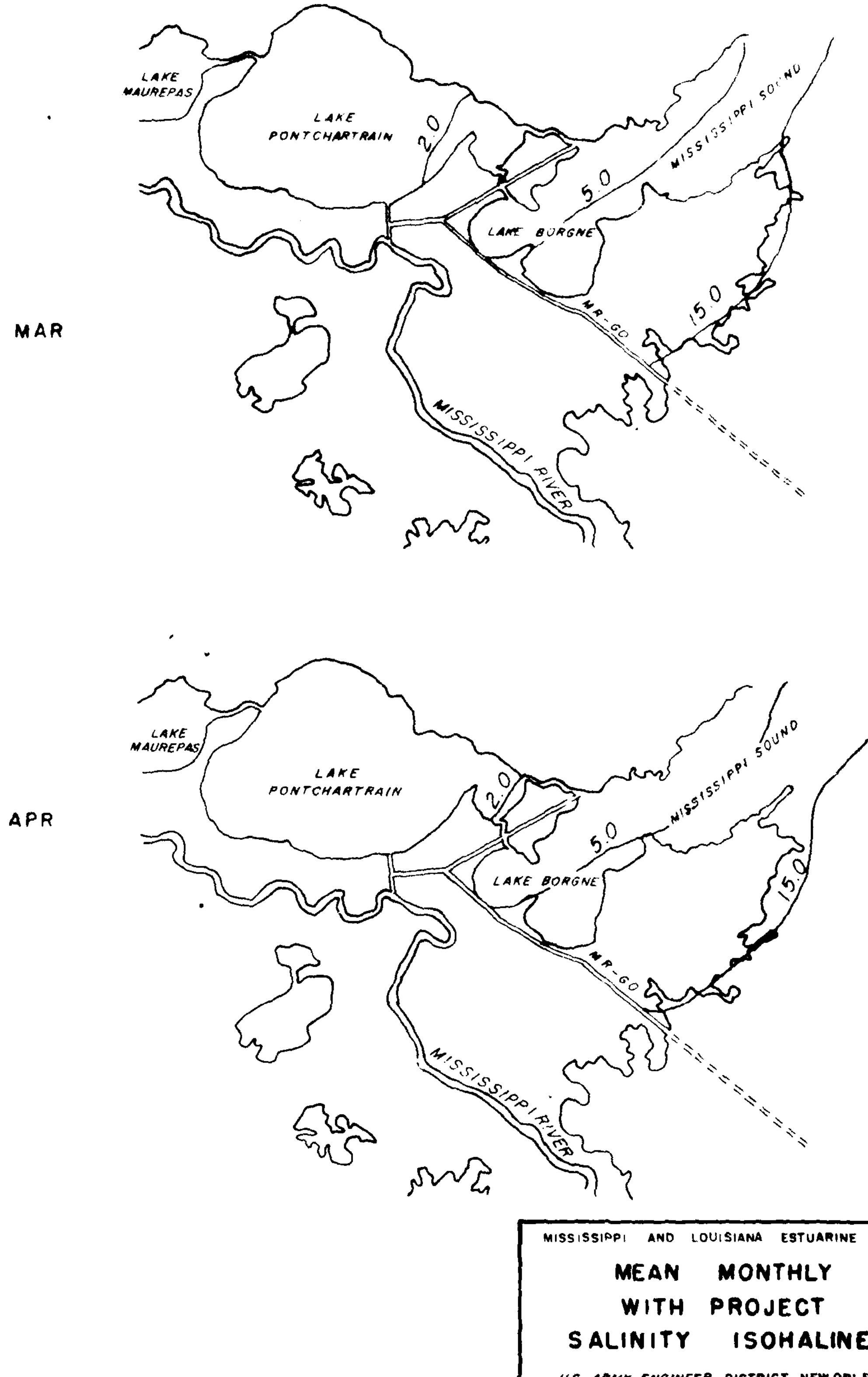
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

MEAN MONTHLY WITH PROJECT SALINITY ISOHALINES

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

PLATE C-12



MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

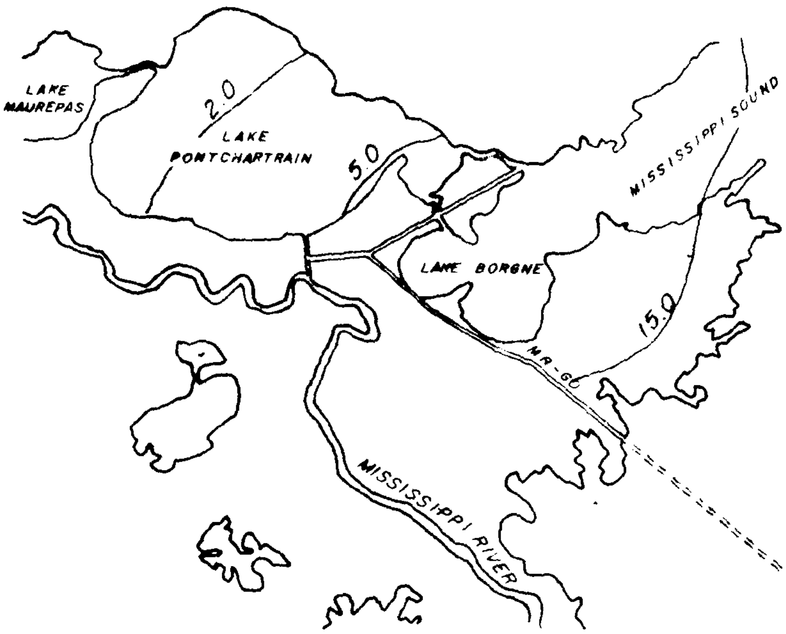
MEAN MONTHLY WITH PROJECT SALINITY ISOHALINES

US ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1964 FILE NO.

PLATE C-11

JAN



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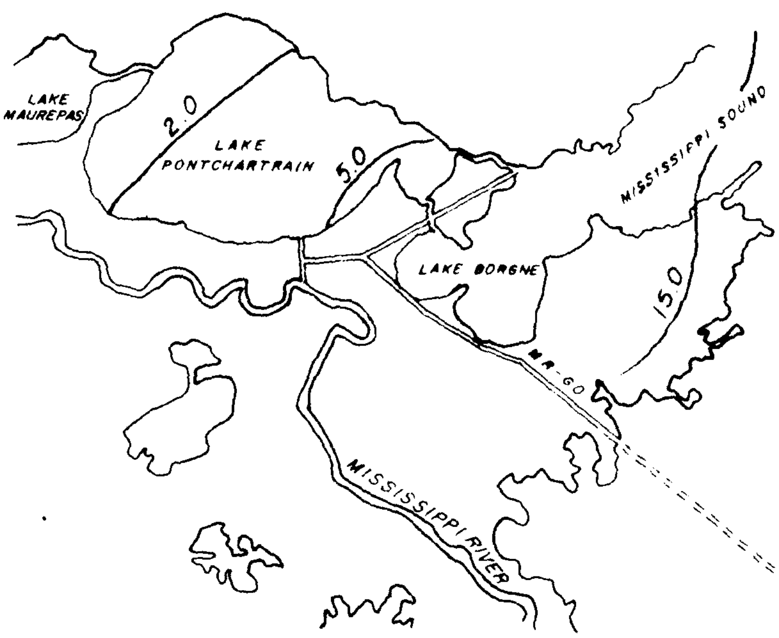

MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

MEAN MONTHLY WITH PROJECT SALINITY ISOHALINES

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

PLATE C-10

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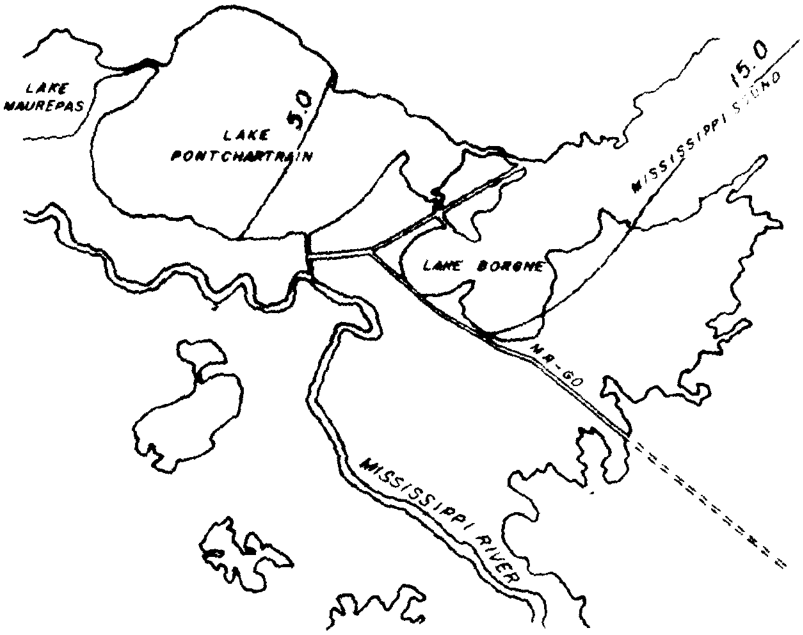

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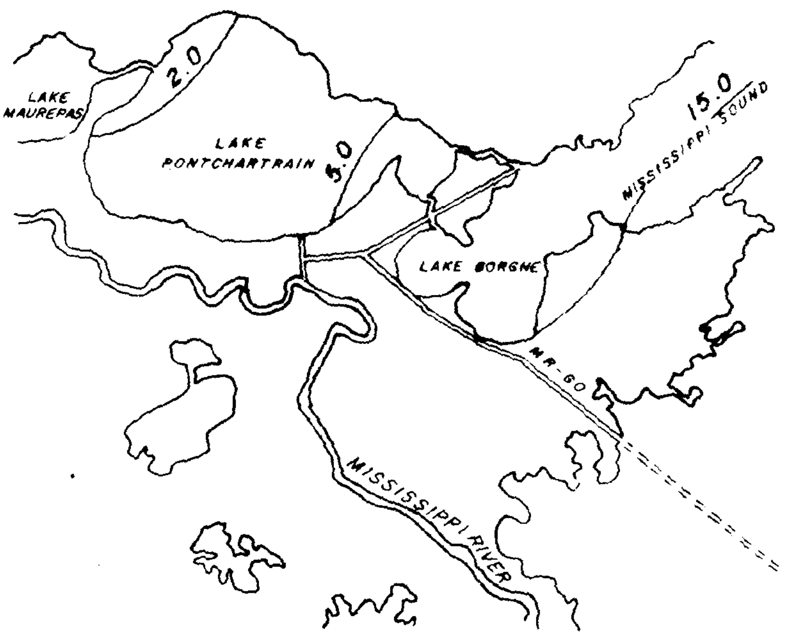
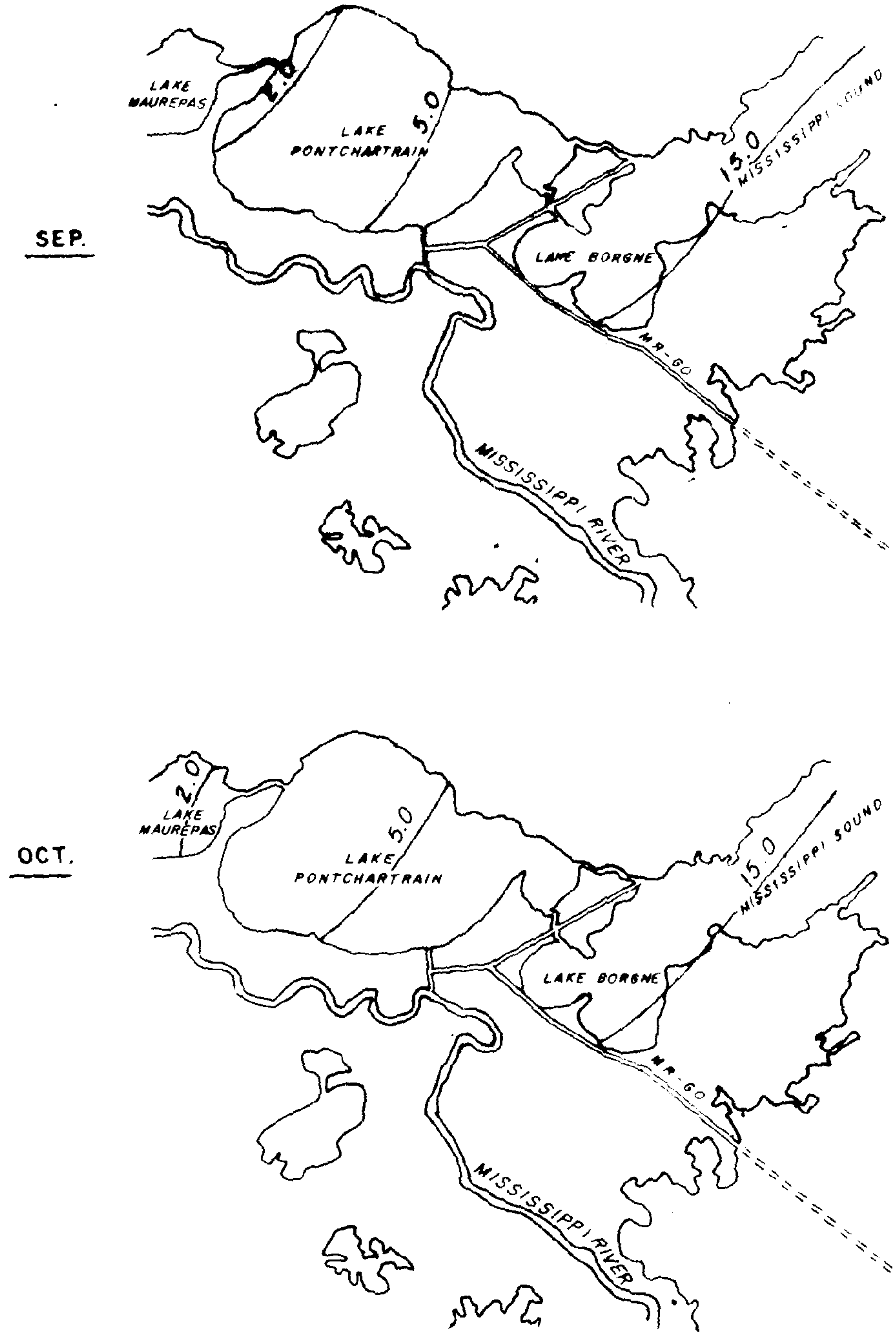


MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

MEAN MONTHLY
WITHOUT PROJECT
SALINITY ISOHALINES

US ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.



MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

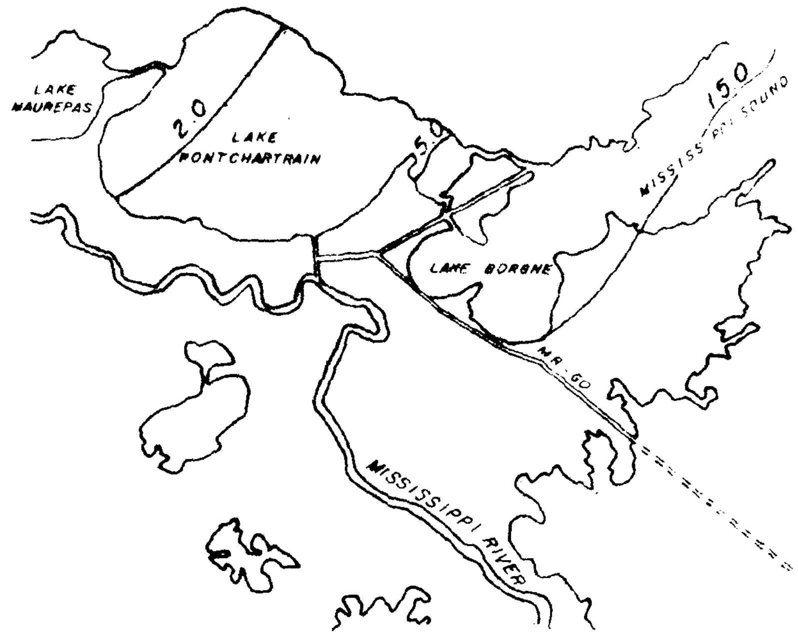
MEAN MONTHLY
WITHOUT PROJECT
SALINITY ISOHALINES

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

PLATE C-8

JULY



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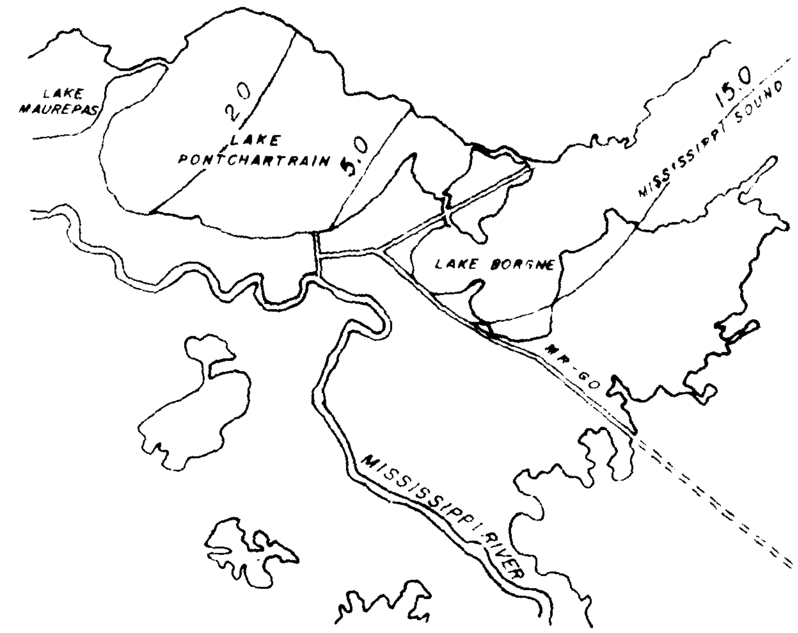


MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

MEAN MONTHLY

WITHOUT PROJECT

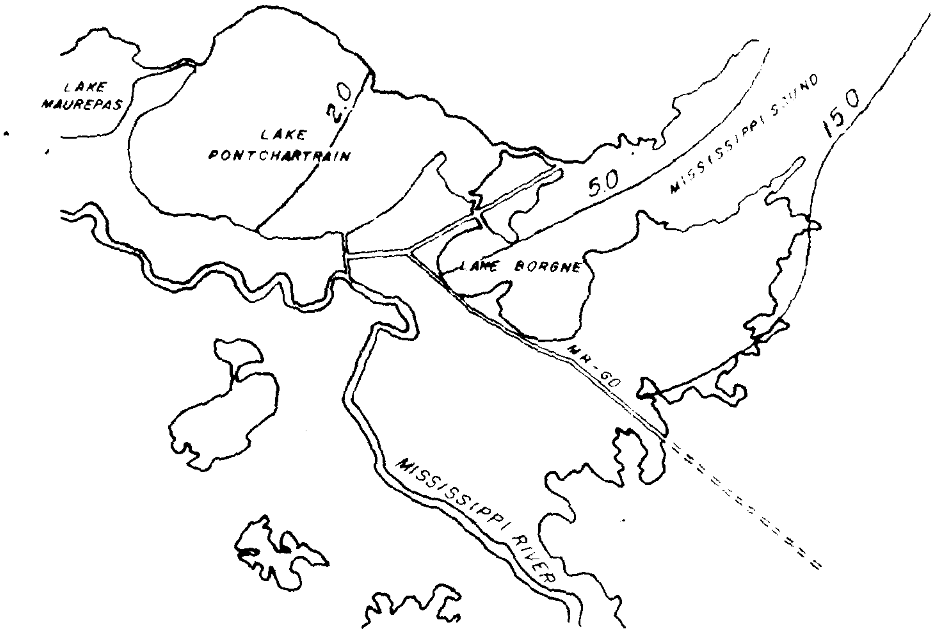
SALINITY ISOHALINES

US ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

PLATE C-7

MAY



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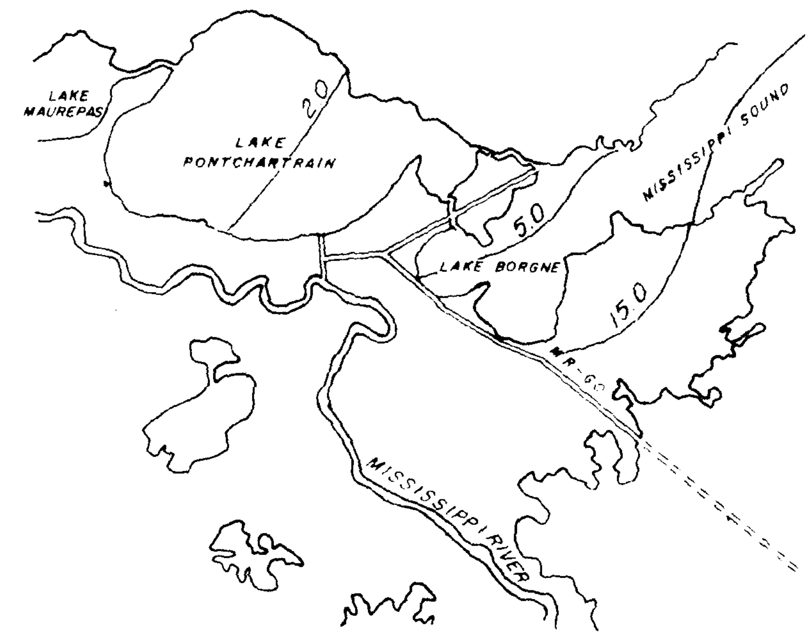


MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

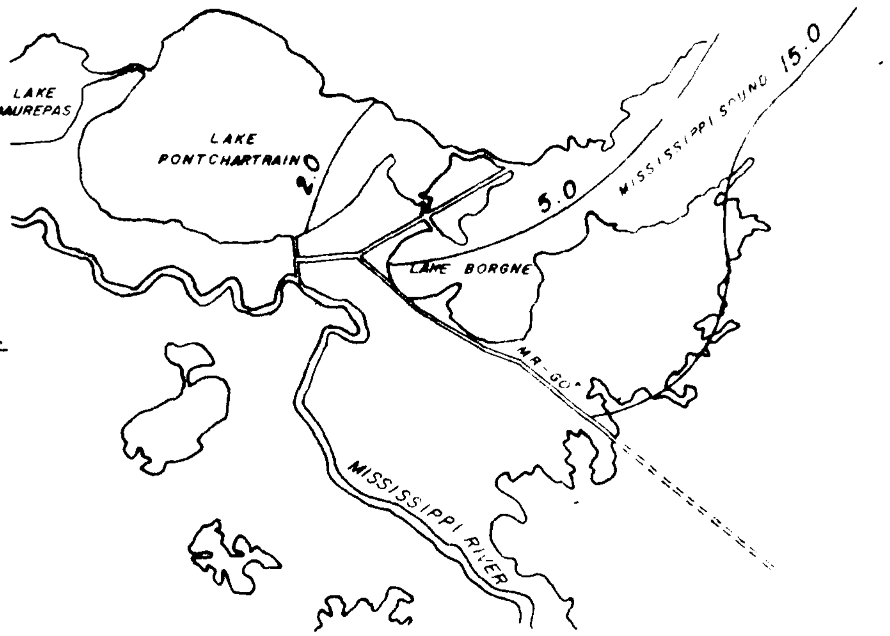
MEAN MONTHLY
WITHOUT PROJECT
SALINITY ISOHALINES

U S ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

PLATE C-6

MAR.



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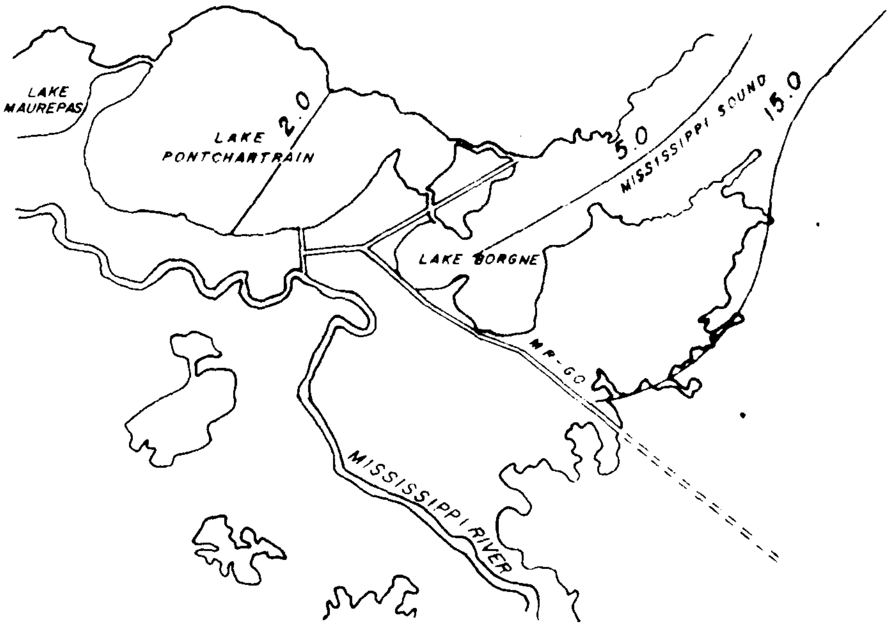


MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

MEAN MONTHLY WITHOUT PROJECT SALINITY ISOHALINES

US ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

PLATE C-5

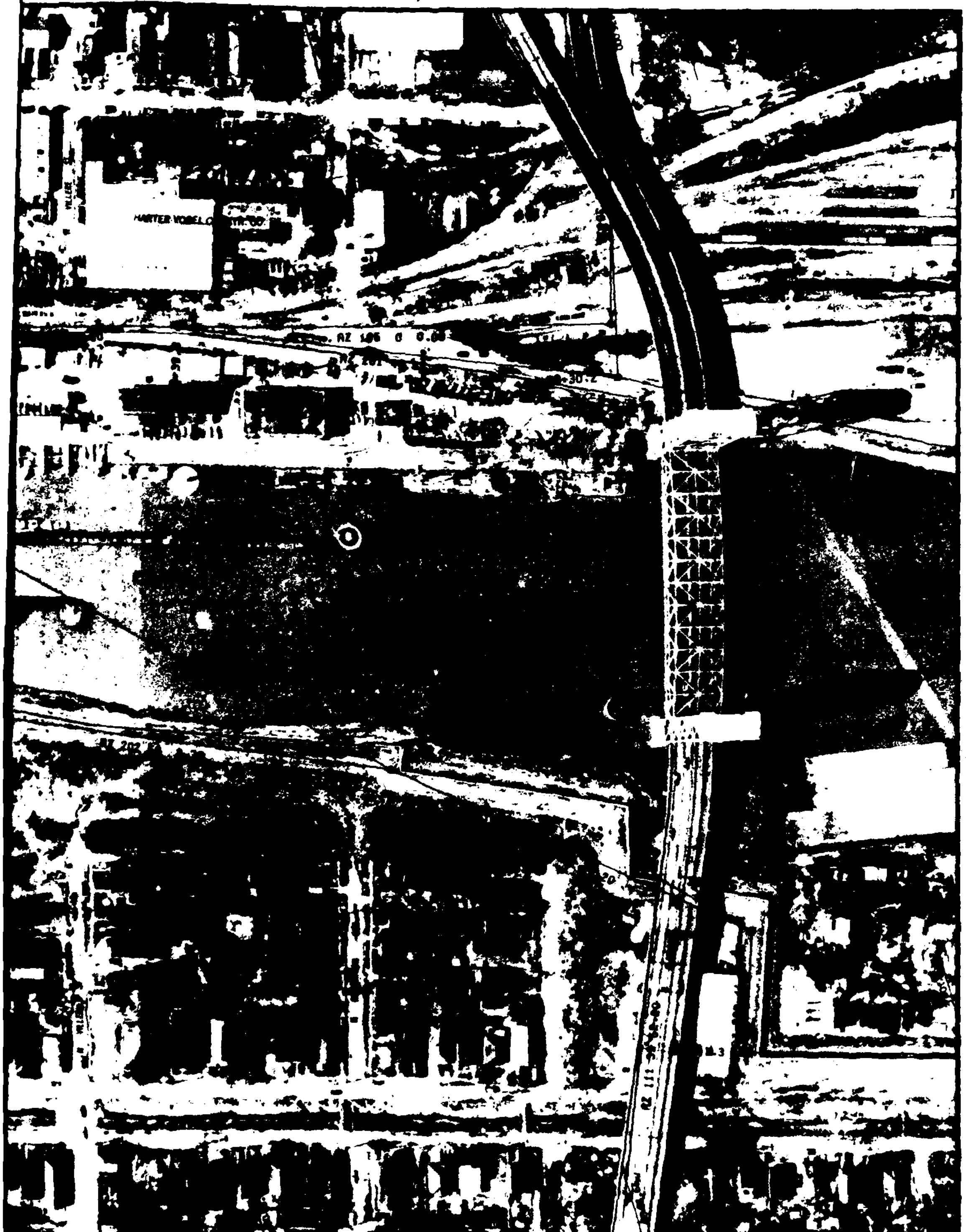
SCALE IN FEET

100 200 300

AREA POLY... PROJECTION 1927
...ATUM IS SHOWN BY SOLID TICKS AND
...CONIC PROJECTION IS SHOWN BY

...RIAL PHOTOS FLOWN JANUARY 1978

2



MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

INNER HARBOR NAVIGATION CANAL
SITE

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

PLATE C-18

SCALE IN FEET

100 0 100 200 3(

NOTES:

INSIDE THE PLAN AREA POLYCONIC PROJECTION
NORTH AMERICAN DATUM IS SHOWN BY SOLID TICK
LAMBERT CONFORMAL CONIC PROJECTION IS SHOW
DASHED TICKS
PREPARED FROM AERIAL PHOTOS FLOWN JANUARY

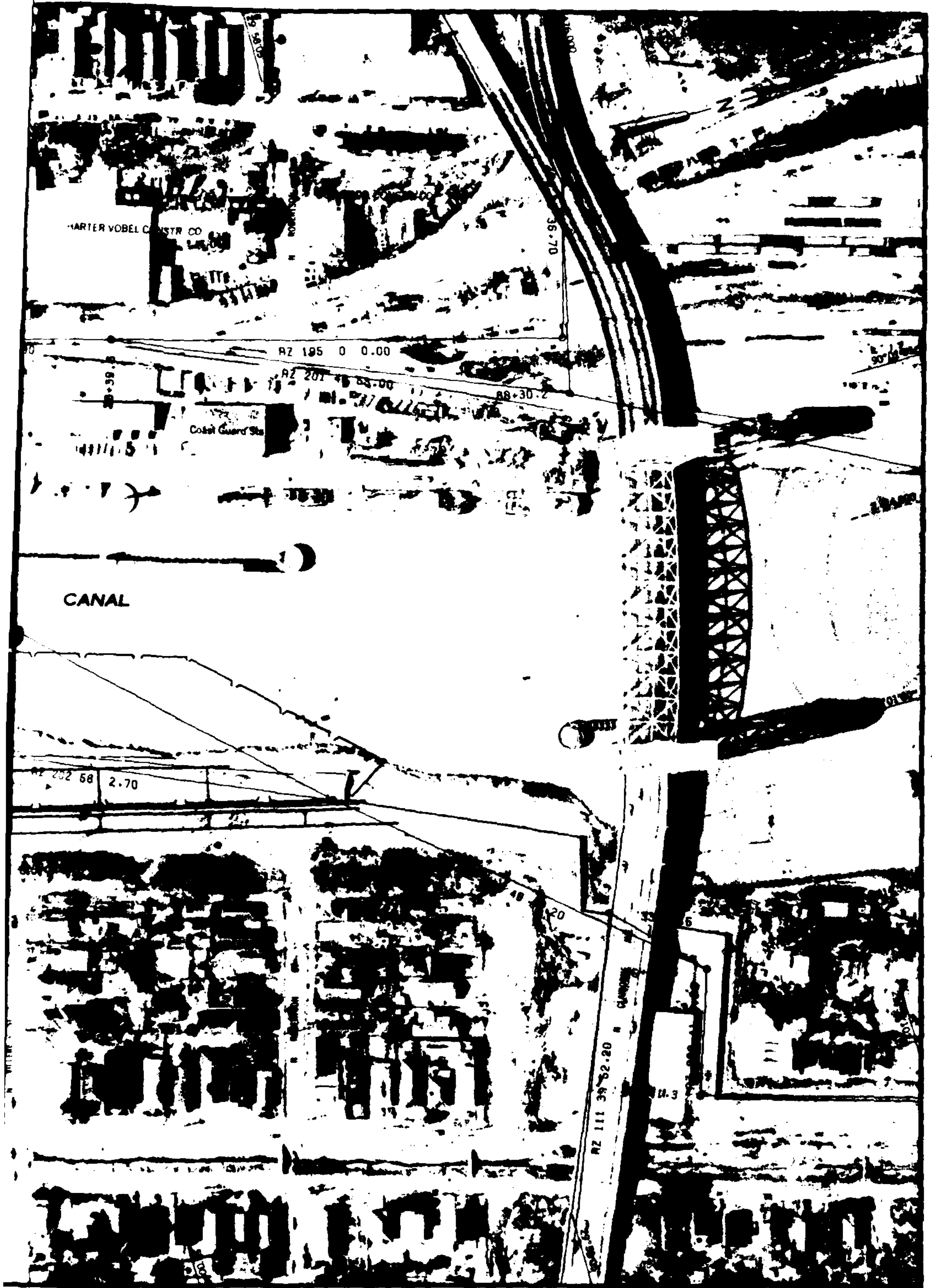
SCALE IN FEET

100 200 300

N AREA POLYCONIC PROJECTION 1927
N DATUM IS SHOWN BY SOLID TICKS AND
ORMAL CONIC PROJECTION IS SHOWN BY

AERIAL PHOTOS FLOWN JANUARY 1978

2



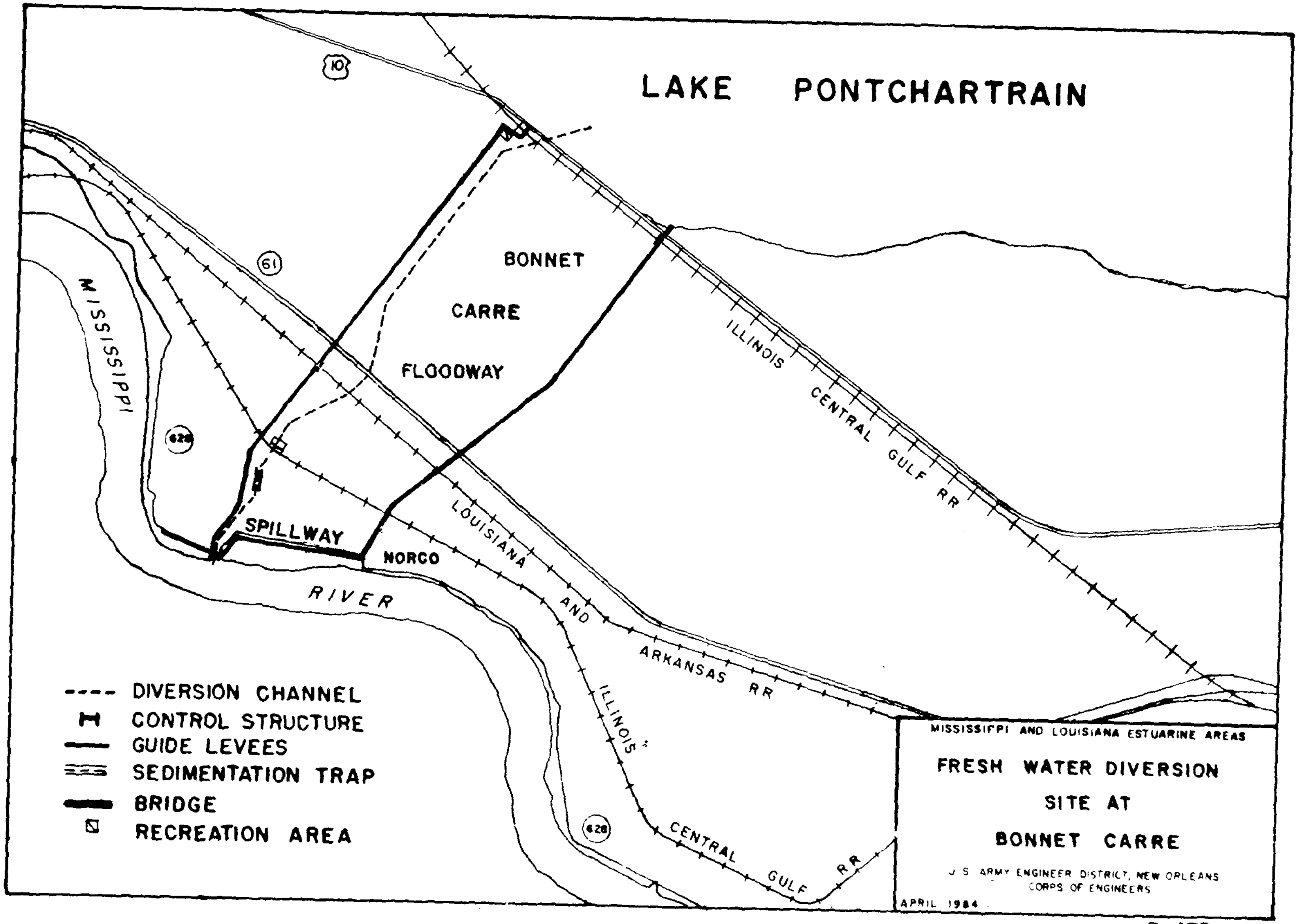
MISSISSIPPI AND LOUISIANA ESTRUARINE AREA

DIVERSION STRUCTURE ADJACENT TO IHNC LOCK

U S ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO 3

PLATE C-19



MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

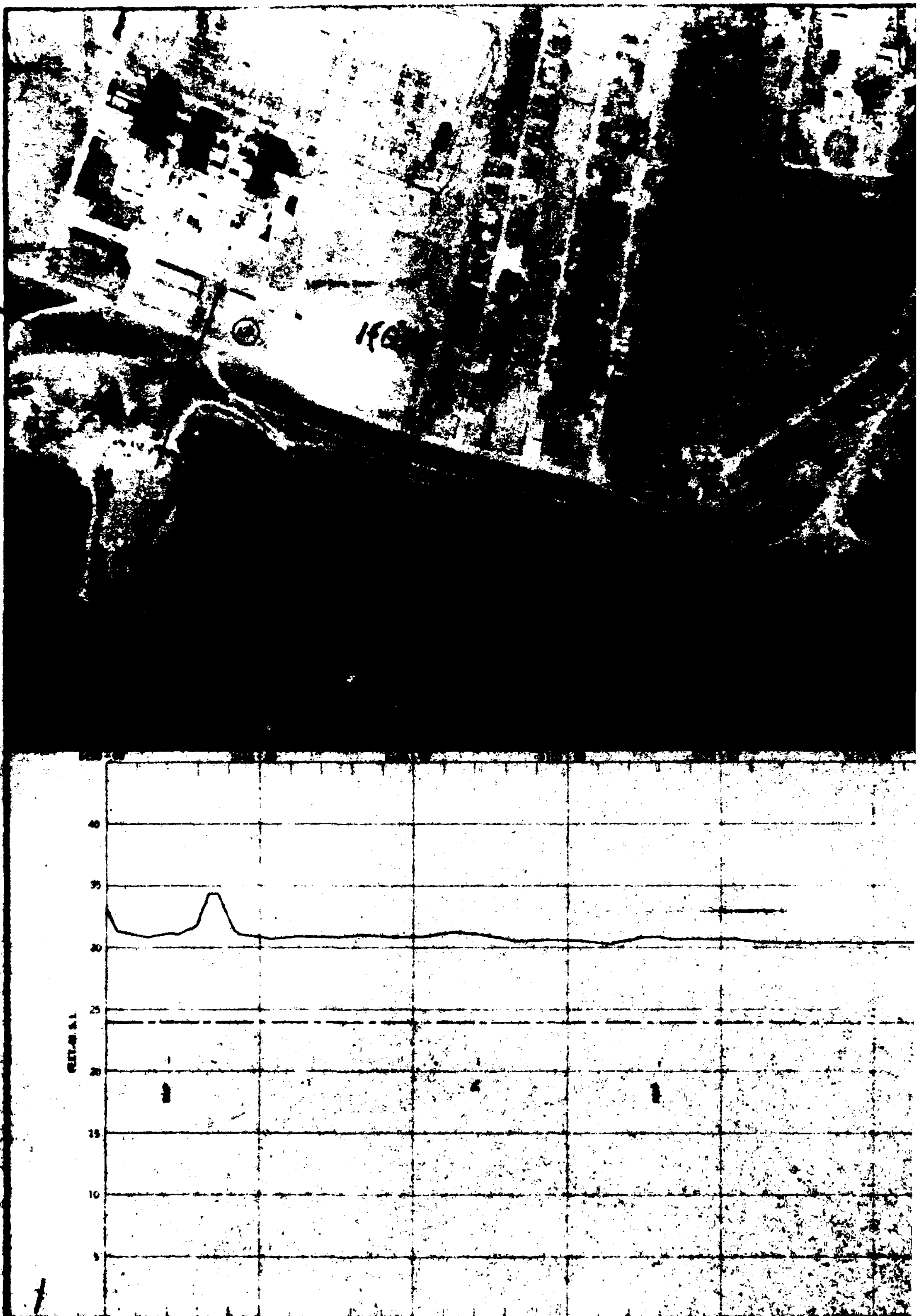
FRESH WATER DIVERSION
SITE AT
BONNET CARRE

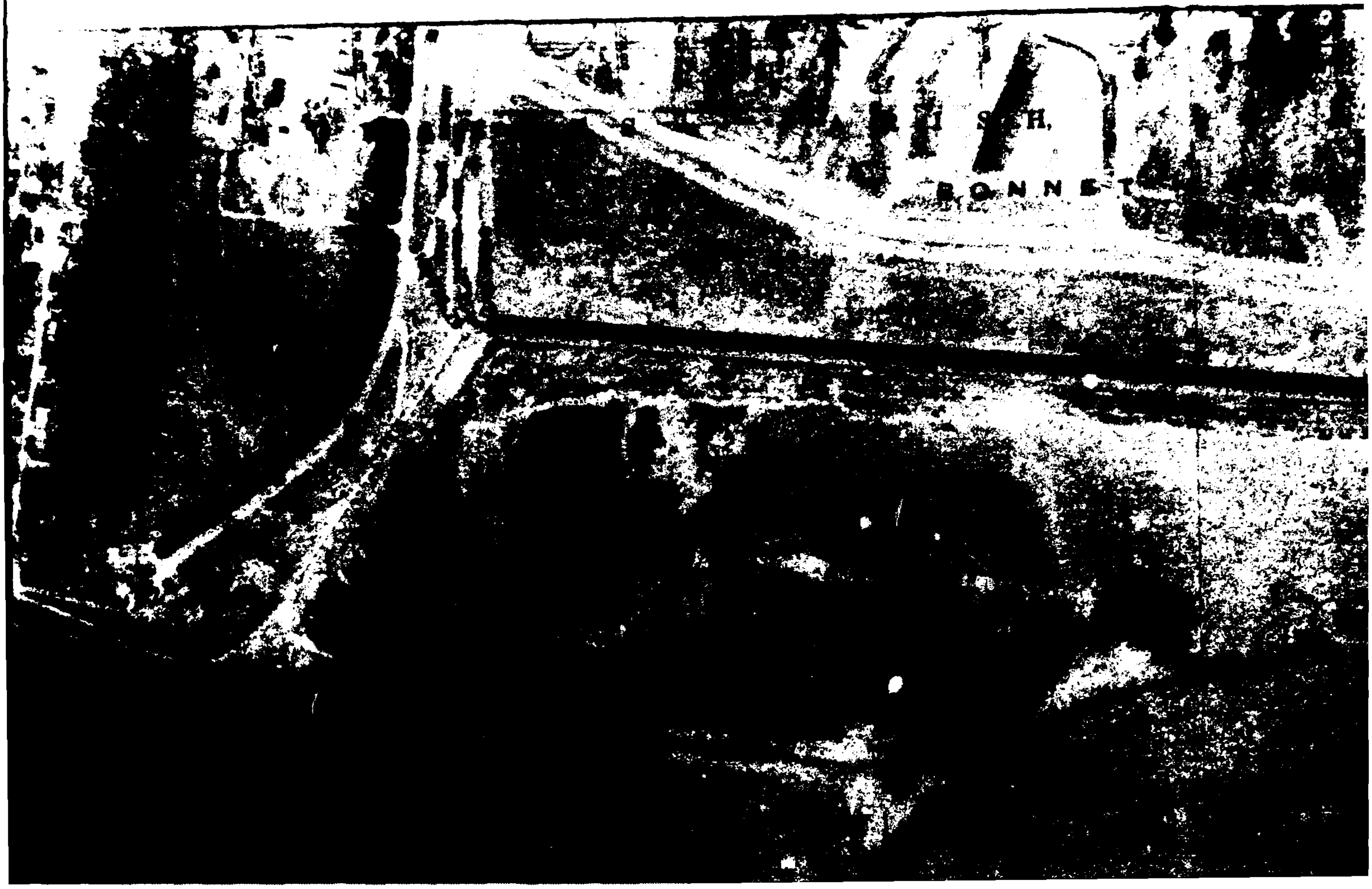
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

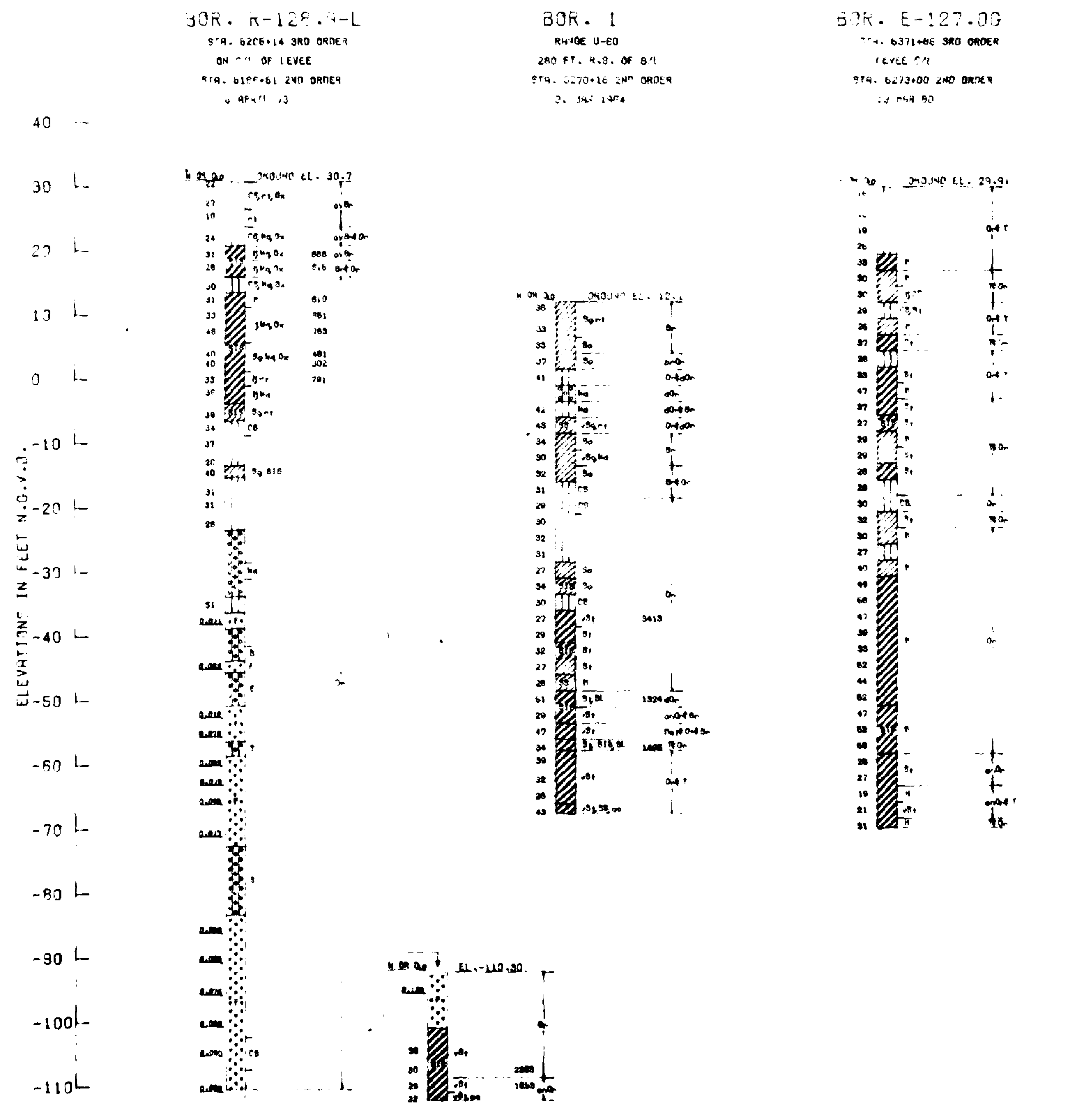
APRIL 1984

PLATE C-20

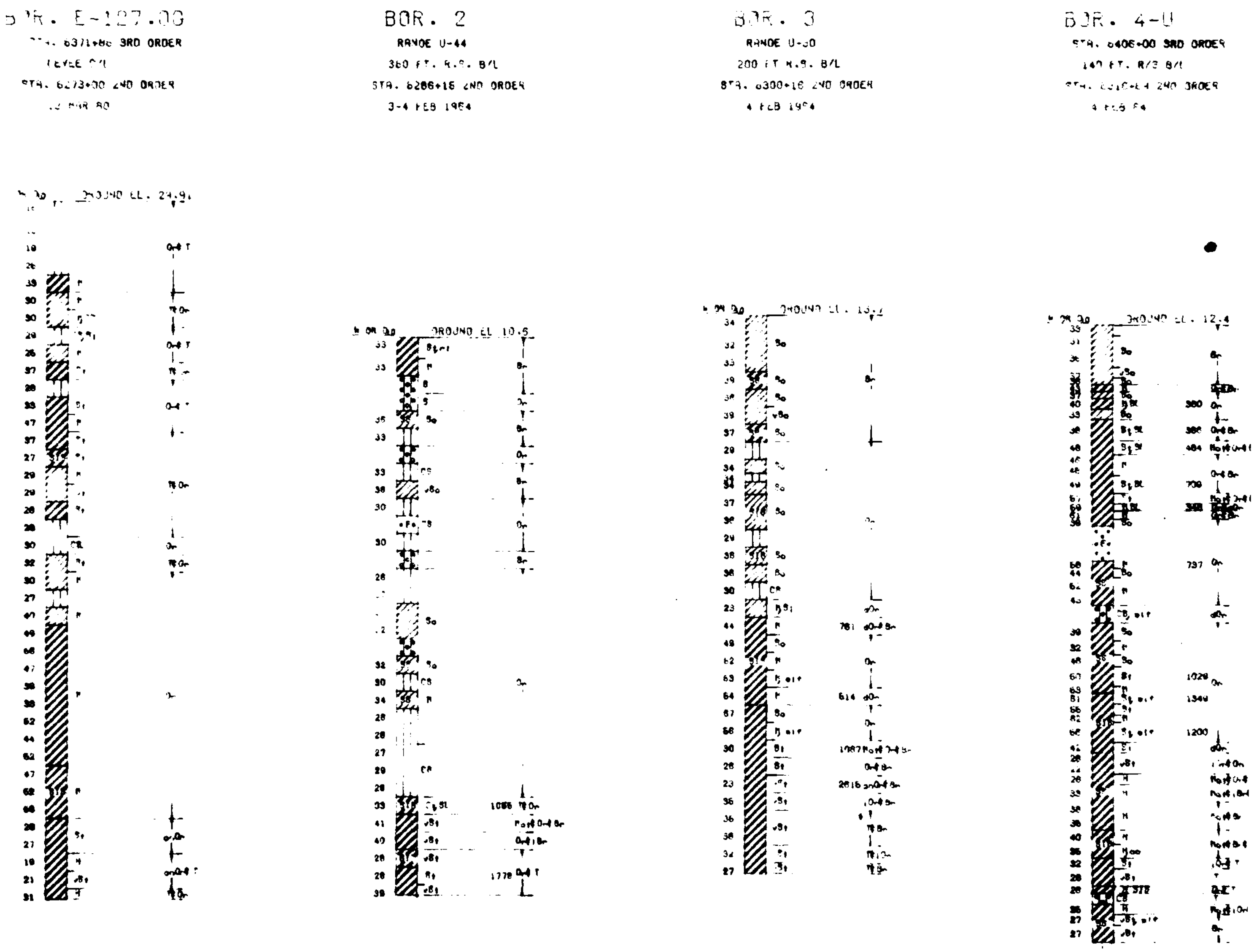
1



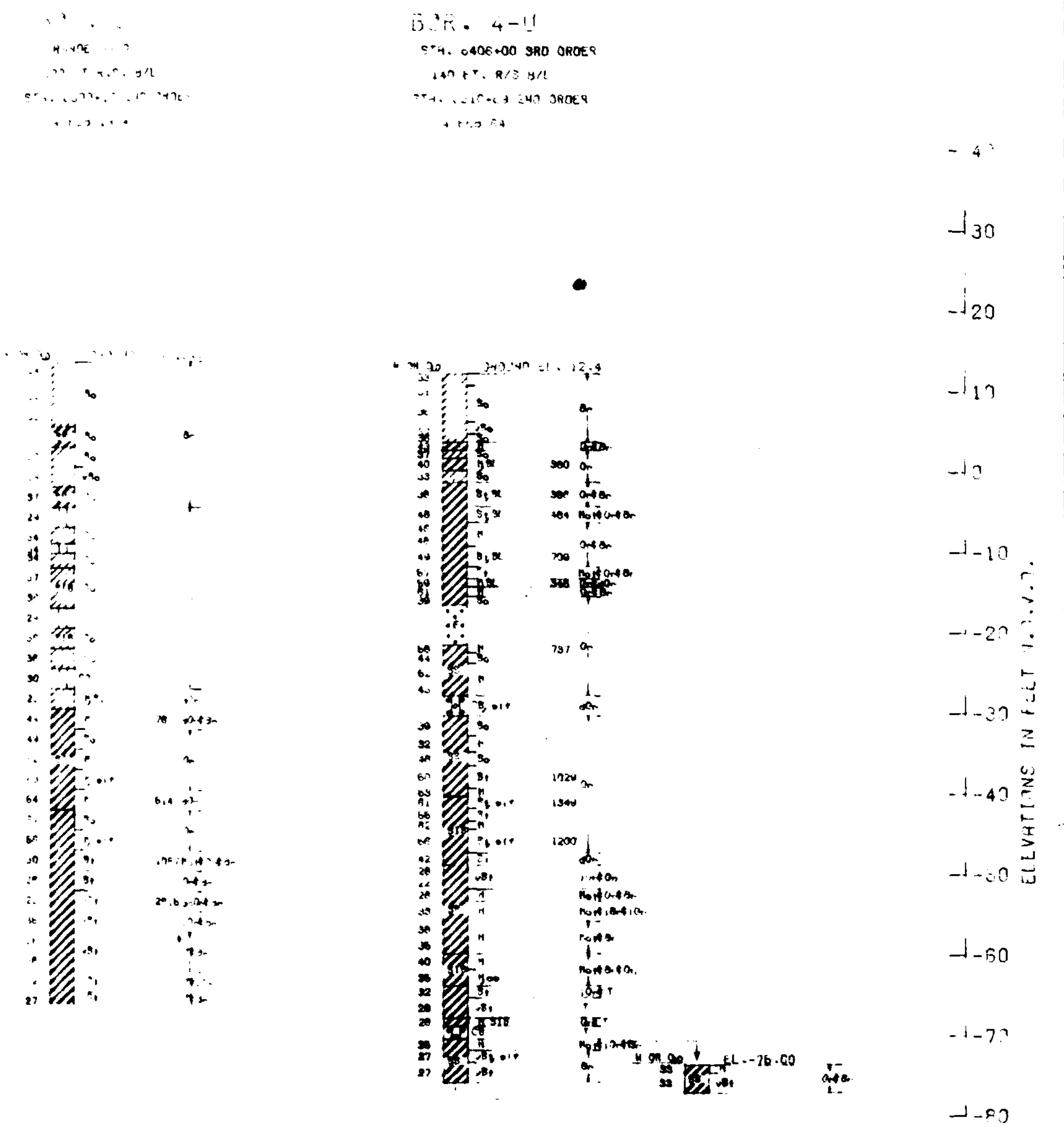

BONNET



BOR. R-128.9-L
STA. 6206+14 3RD ORDER
ON C/L OF LEVEE
STA. 6199+61 2ND ORDER
BOR. 1
RHODE U-60
280 FT. R.S. OF B/L
STA. 6270+16 2ND ORDER
BOR. E-127.0G
STA. 6371+86 3RD ORDER
LEVEE C/L
STA. 6273+00 2ND ORDER
ELEVATIONS IN FEET N.G.V.D.
GROUND EL. 30.7
GROUND EL. 29.9
EL. -110.30
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110


BOR. 2
RANGE U-44
360 FT. R.S. B/L
STA. 6286+15 2ND ORDER
3-4 FEB 1954
GROUND EL 10.5
BOR. 3
RANGE U-30
200 FT. R.S. B/L
4 FEB 1954
BOR. 4-U
STA. 6406+00 3RD ORDER
GROUND EL. 12.4

2



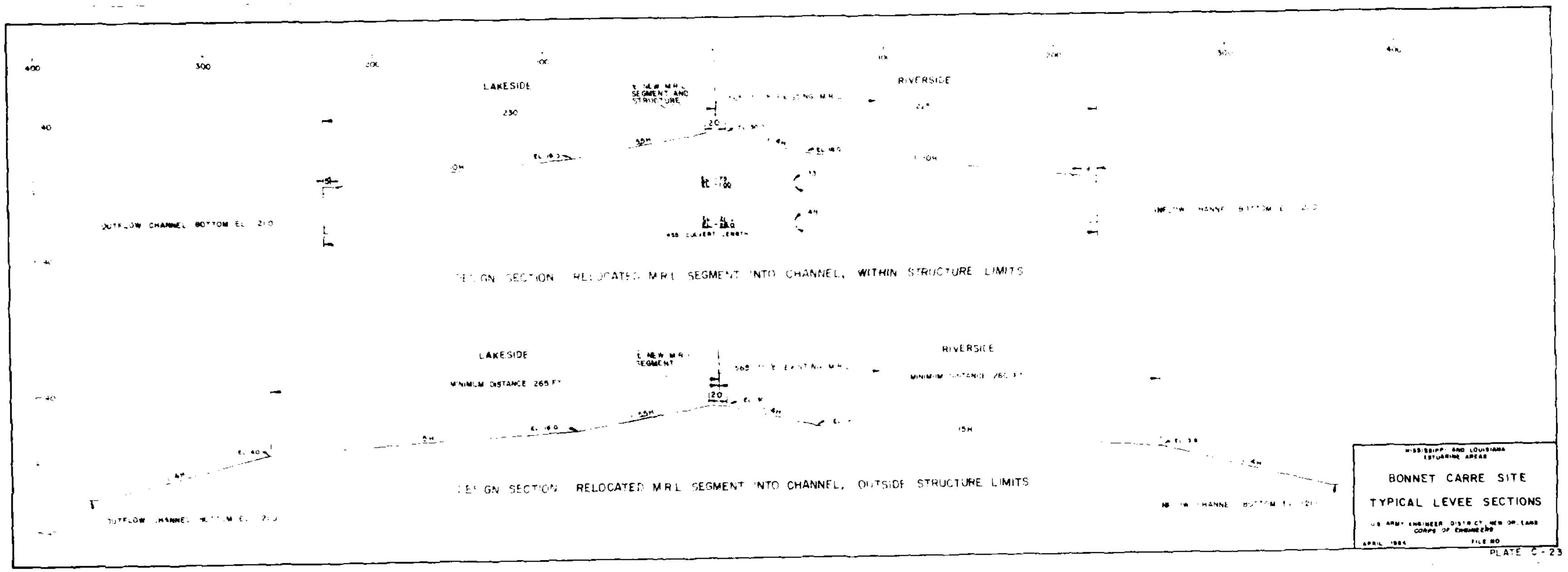
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

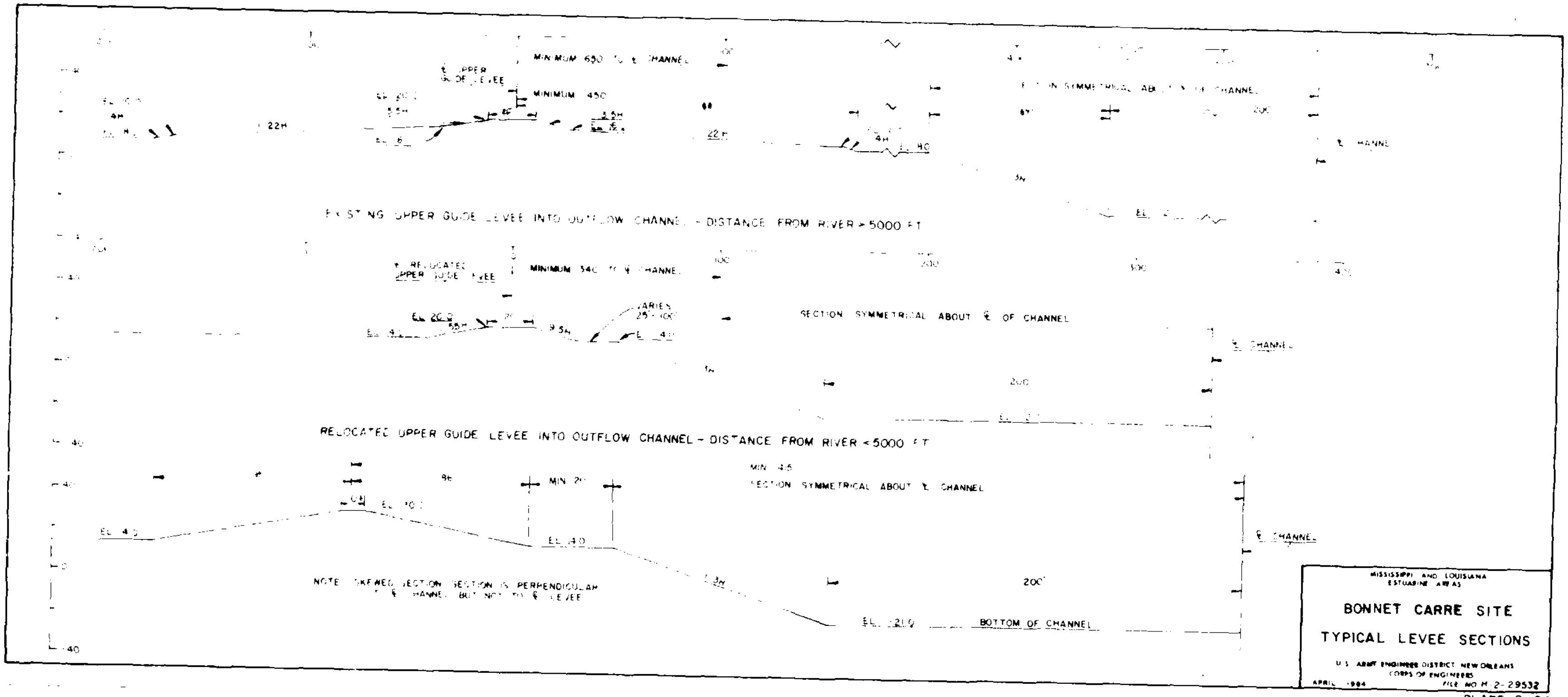
SOIL BORING DATA
MILE 133.0 TO MILE 121.0-L

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

PLATE C-22 3


LAKESIDE
RIVERSIDE
230
OUTFLOW CHANNEL BOTTOM EL. 21.0
DESIGN SECTION RELOCATED M.R.L. SEGMENT INTO CHANNEL, WITHIN STRUCTURE LIMITS
MINIMUM DISTANCE 265 FT
DESIGN SECTION RELOCATED M.R.L. SEGMENT INTO CHANNEL, OUTSIDE STRUCTURE LIMITS
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS
BONNET CARRE SITE
TYPICAL LEVEE SECTIONS
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
APRIL 1984
FILE NO.
PLATE C-23



MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

BONNET CARRE SITE

TYPICAL LEVEE SECTIONS

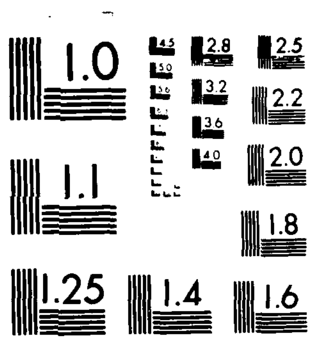
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

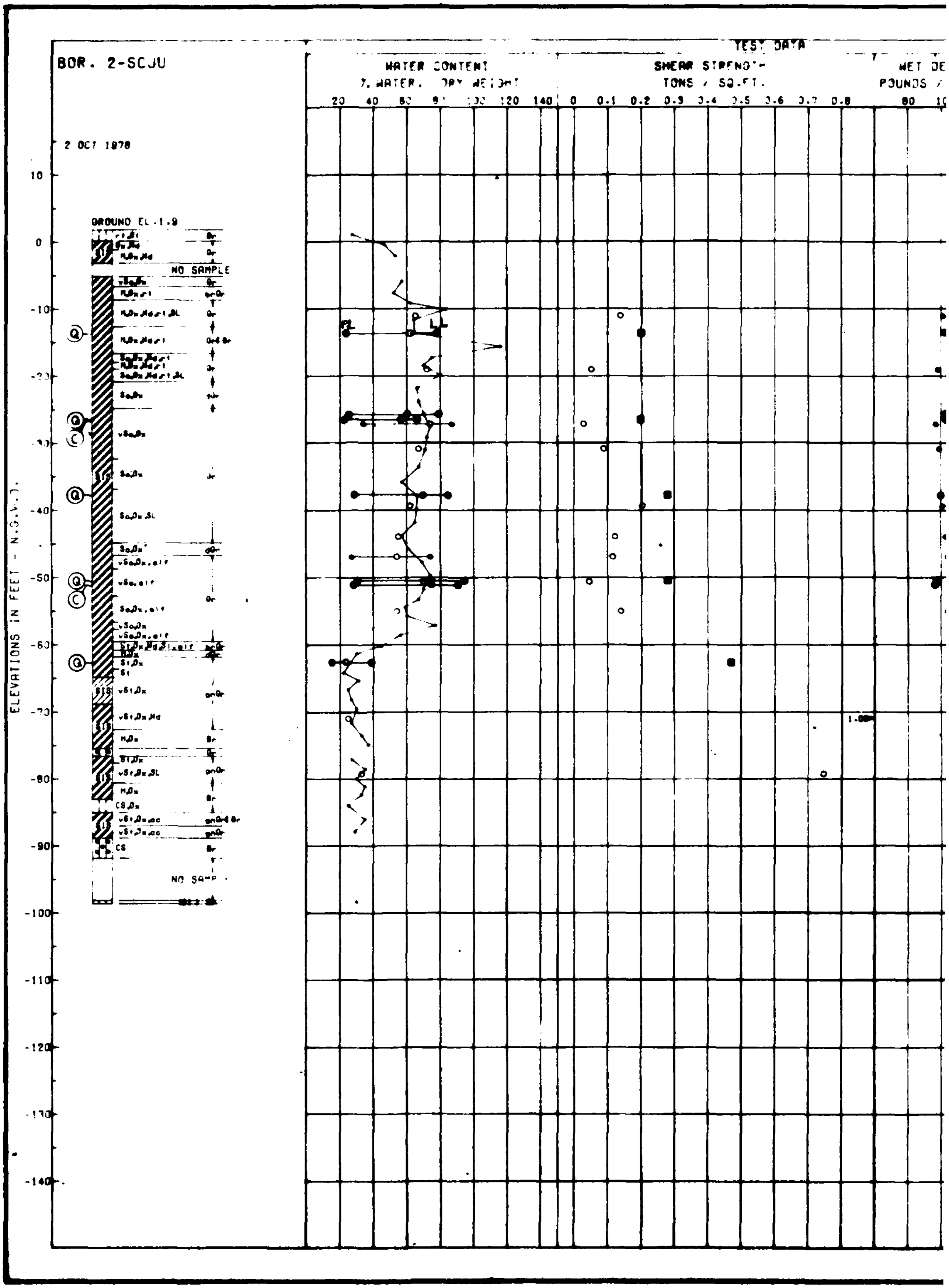
APRIL 1984 FILE NO. H-2-29532

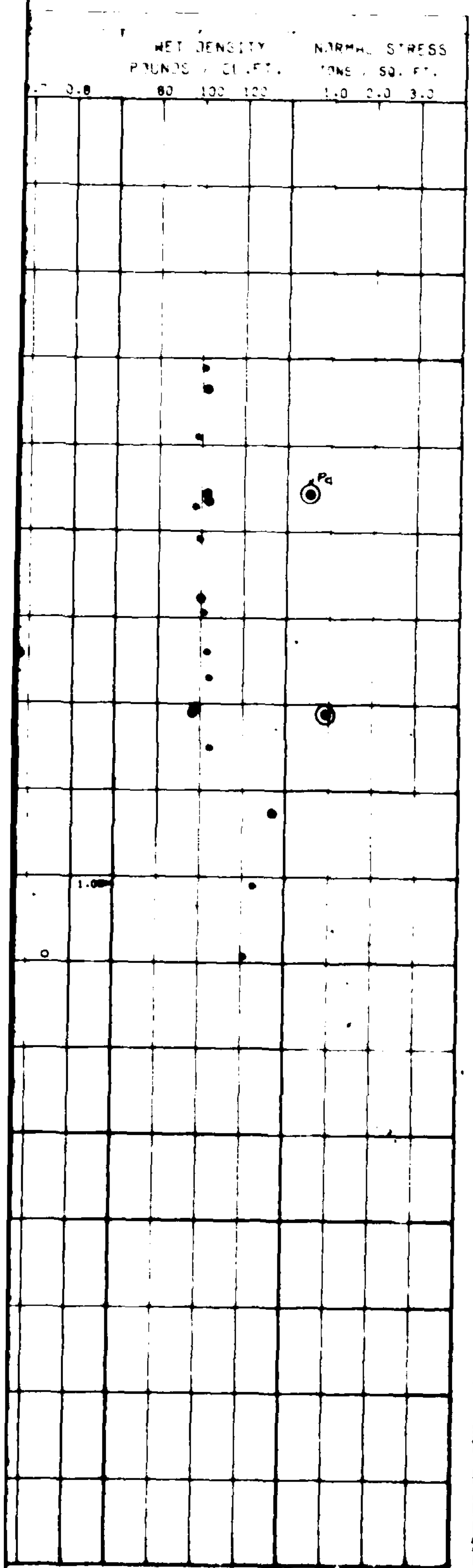
PLATE C-24

AD-A152 729 MISSISSIPPI AND LOUISIANA ESTUARINE AREAS FRESHWATER DIVERSION TO LAKE PO..(U) ARMY ENGINEER DISTRICT NEW ORLEANS LA D L CHEW APR 84 5/6

UNCLASSIFIED F/G 13/2 NL


1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6


BOR. 2-SCJU
2 OCT 1978
GROUND EL 1.9
NO SAMPLE
ELEVATIONS IN FEET - N.G.V.D.
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
TEST DATA
WATER CONTENT
% WATER, DRY WEIGHT
20
40
60
120
140
SHEAR STRENGTH
TONS / SQ.FT.
0
0.1
0.2
0.3
0.8
WET DE
POUNDS /
80



CONSOLIDATION DATA

O- (UC) UNCONFINED COMPRESSION TEST
●- (Q) UNCONSOLIDATED - UNDRAINED SHEAR TEST
- (R) CONSOLIDATED - UNDRAINED SHEAR TEST
- (S) CONSOLIDATED - DRAINED SHEAR TEST

BORINGS WERE TAKEN WITH A 5 INCH DIAMETER STEEL TUBE PISTON TYPE SAMPLER

FOR SOIL BORING LEGEND SEE PLATE A

FOR LOCATION OF BORINGS SEE PLATE

MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

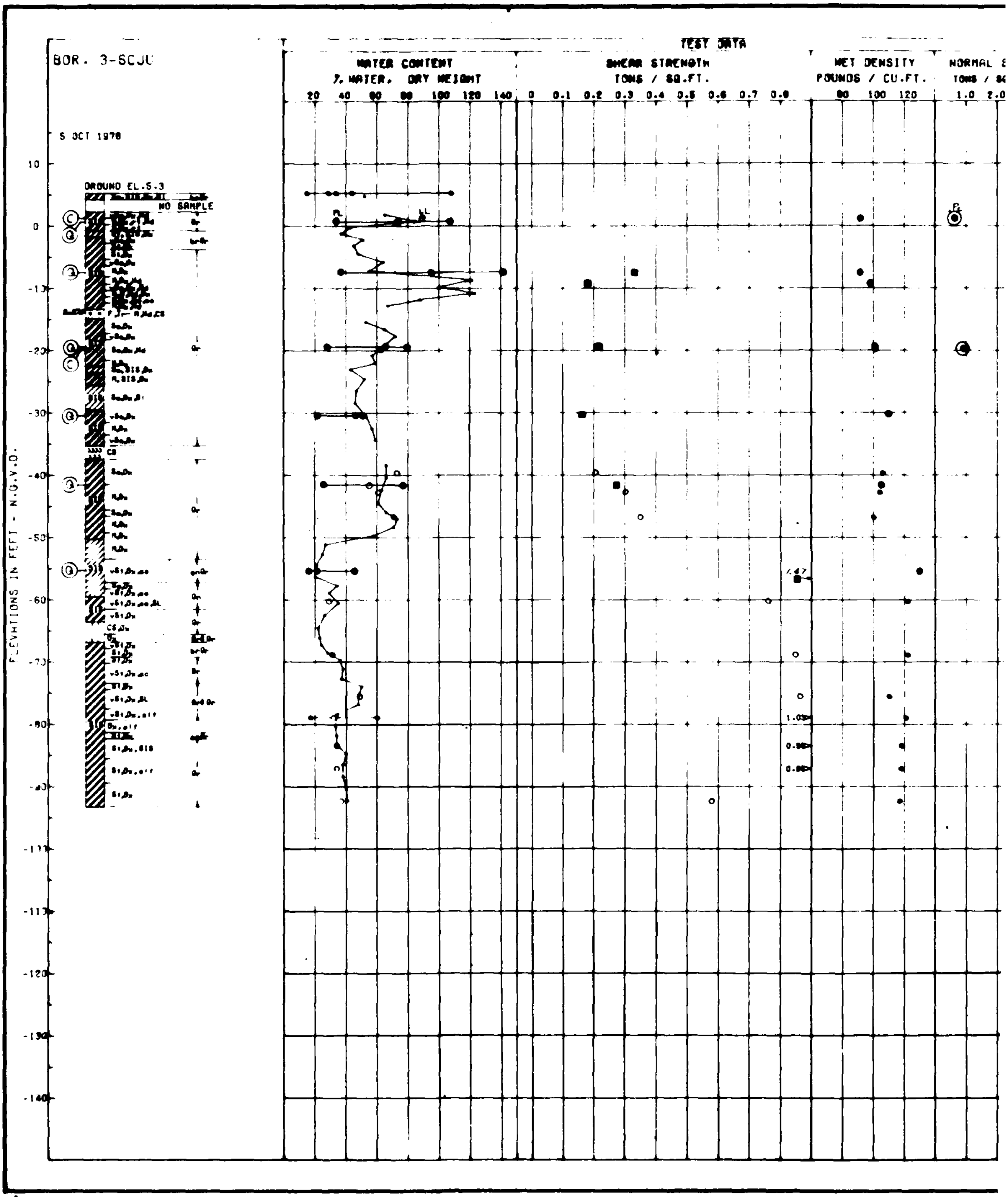
BORING 2-SCJU

US ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

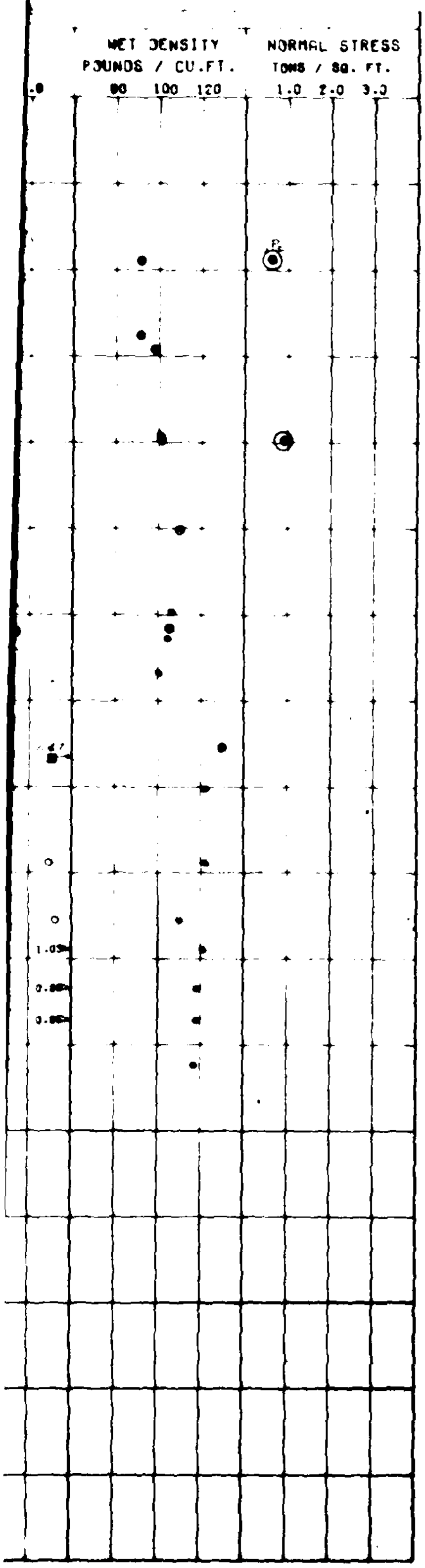
APRIL 1984 FILE NO.

PLATE C-25

2



BOR. 3-SCJU
5 OCT 1978
GROUND EL. 5.3
NO SAMPLE
TEST DATA
WATER CONTENT
% WATER, DRY WEIGHT
20 40 60 80 100 120 140
SHEAR STRENGTH
TONS / SQ.FT.
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8
WET DENSITY
POUNDS / CU.FT.
80 100 120
NORMAL
1.0 2.0
ELEVATIONS IN FEET - N.G.V.D.
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140
PL
LL



CONSOLIDATION DATA

○ - (UC) UNCONFINED COMPRESSION TEST
● - (Q) UNCONSOLIDATED - UNDRAINED SHEAR TEST
- (R) CONSOLIDATED - UNDRAINED SHEAR TEST
- (S) CONSOLIDATED - DRAINED SHEAR TEST

BORINGS WERE TAKEN WITH A 5 INCH DIAMETER
STEEL TUBE PISTON TYPE SAMPLER

FOR SOIL BORING LEGEND SEE PLATE A
FOR LOCATION OF BORINGS SEE PLATE

MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

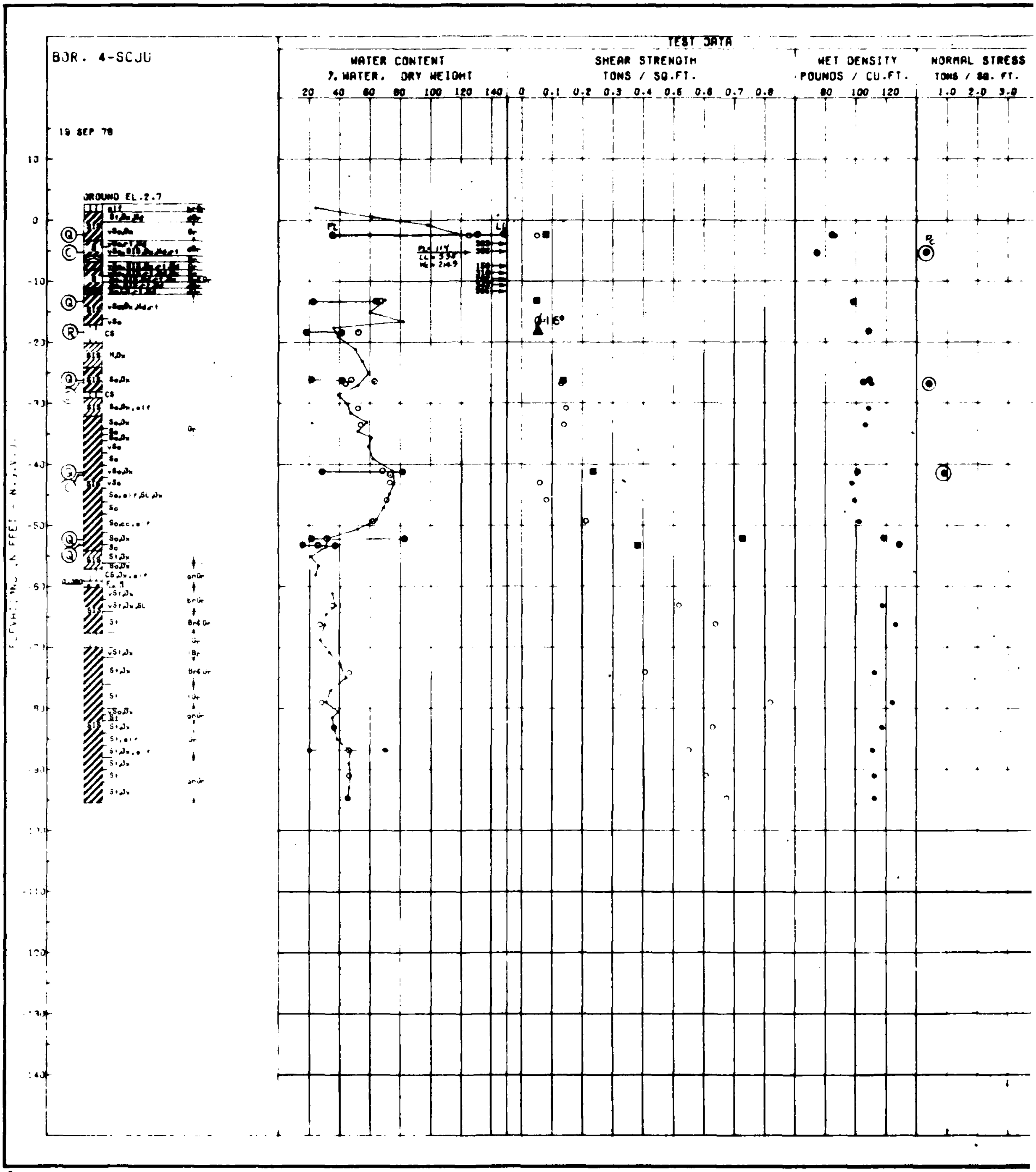
BORING 3-SCJU

US ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

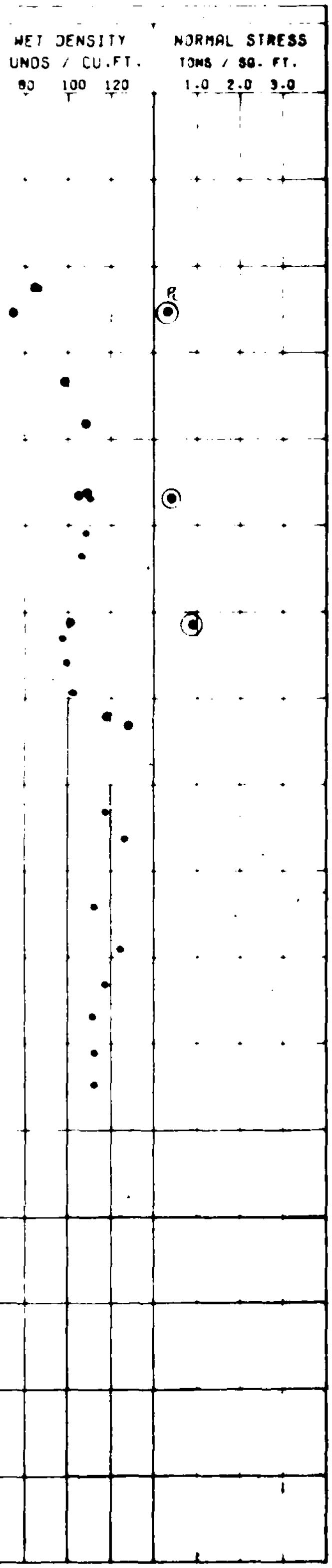
APRIL 1984 FILE NO.

PLATE C-26

2



BOR. 4-SCJU
19 SEP 78
GROUND EL.-2.7
TEST DATA
WATER CONTENT
% WATER, DRY WEIGHT
20 40 60 80 100 120 140
SHEAR STRENGTH
TONS / SQ.FT.
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8
WET DENSITY
POUNDS / CU.FT.
80 100 120
NORMAL STRESS
TONS / SQ. FT.
1.0 2.0 3.0
PL
LL



CONSOLIDATION DATA

- (UC) UNCONFINED COMPRESSION TEST
- (Q) UNCONSOLIDATED - UNDRAINED SHEAR TEST
- (R) CONSOLIDATED - UNDRAINED SHEAR TEST
- (S) CONSOLIDATED - DRAINED SHEAR TEST

BORINGS WERE TAKEN WITH A 5 INCH DIAMETER STEEL TUBE PISTON TYPE SAMPLER

FOR SOIL BORING LEGEND SEE PLATE A

FOR LOCATION OF BORINGS SEE PLATE

MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

BORING 4-SCJU

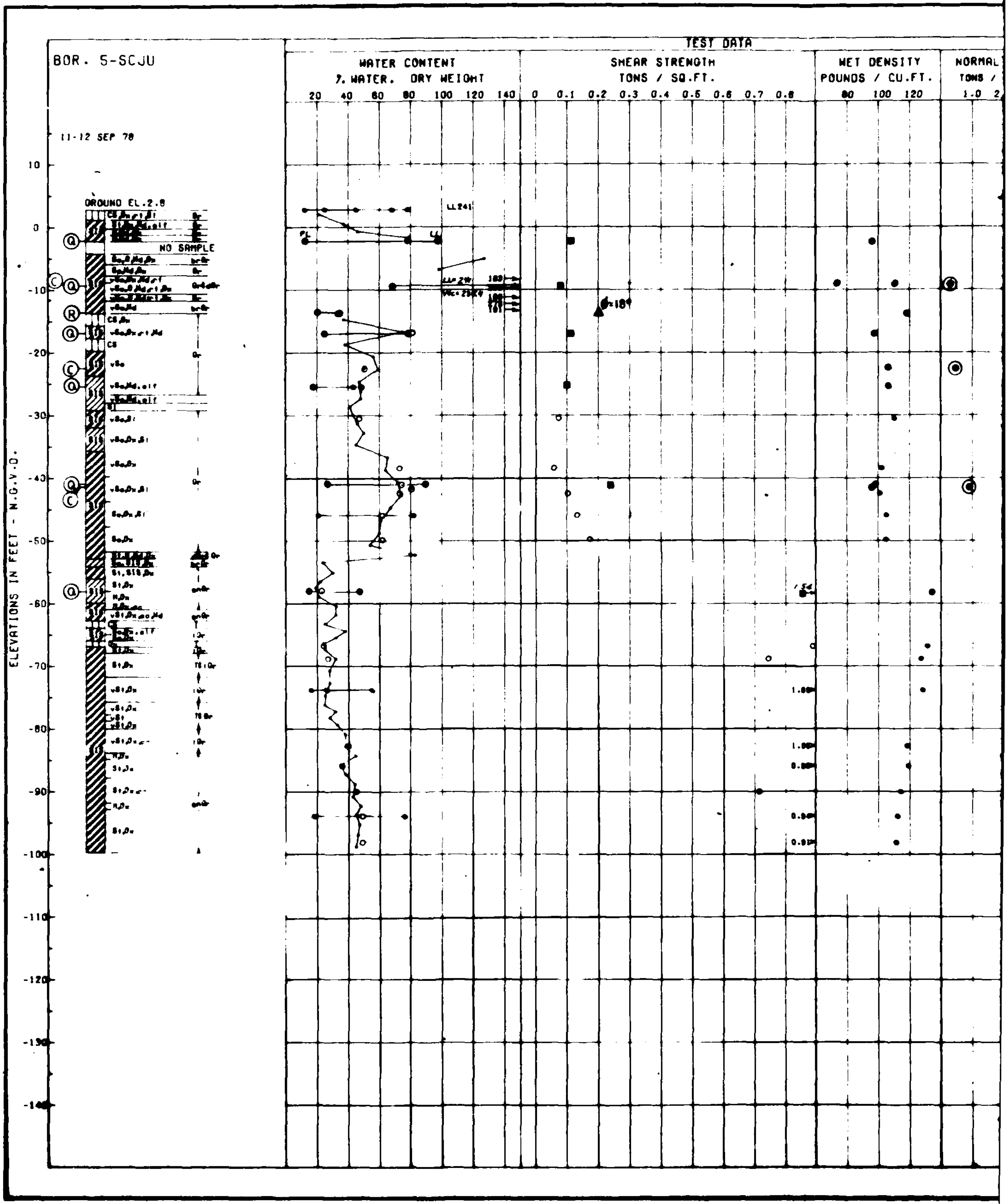
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

PLATE C-?7

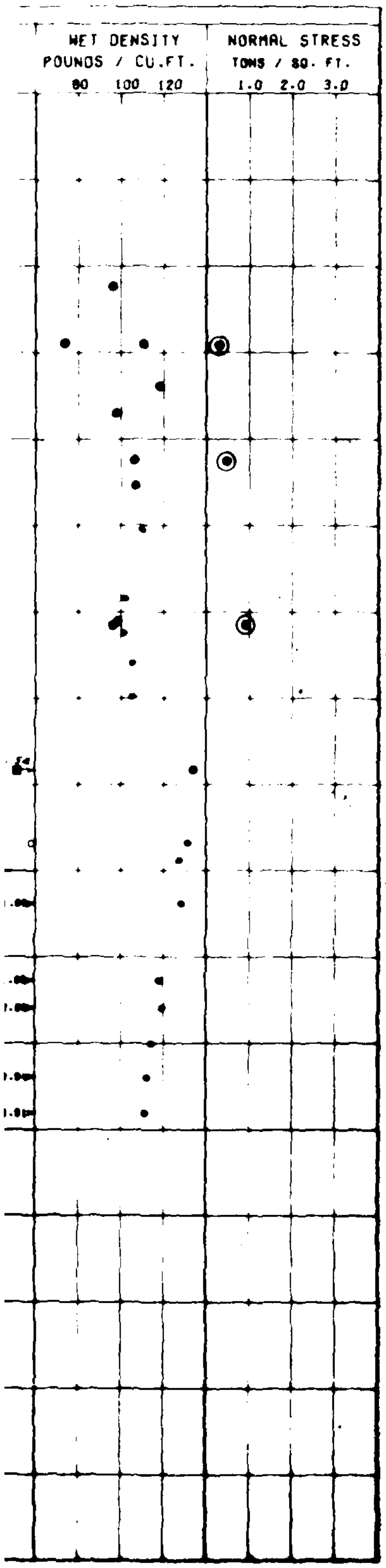
1 2

1


BOR. 5-SCJU
11-12 SEP 78
GROUND EL. 2.8
NO SAMPLE
ELEVATIONS IN FEET - N.G.V.D.
TEST DATA
WATER CONTENT
% WATER. DRY WEIGHT
20 40 60 80 100 120 140
SHEAR STRENGTH
TONS / SQ.FT.
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8
WET DENSITY
POUNDS / CU.FT.
80 100 120
NORMAL
TONS /
1.0 2
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140

1

2



CONSOLIDATION DATA

O - (UC) UNCONFINED COMPRESSION TEST
■ - (Q) UNCONSOLIDATED - UNDRAINED SHEAR TEST
▲ - (R) CONSOLIDATED - UNDRAINED SHEAR TEST
- (S) CONSOLIDATED - DRAINED SHEAR TEST
BORINGS WERE TAKEN WITH A 5 INCH DIAMETER STEEL TUBE PISTON TYPE SAMPLER
FOR SOIL BORING LEGEND SEE PLATE A
FOR LOCATION OF BORINGS SEE PLATE

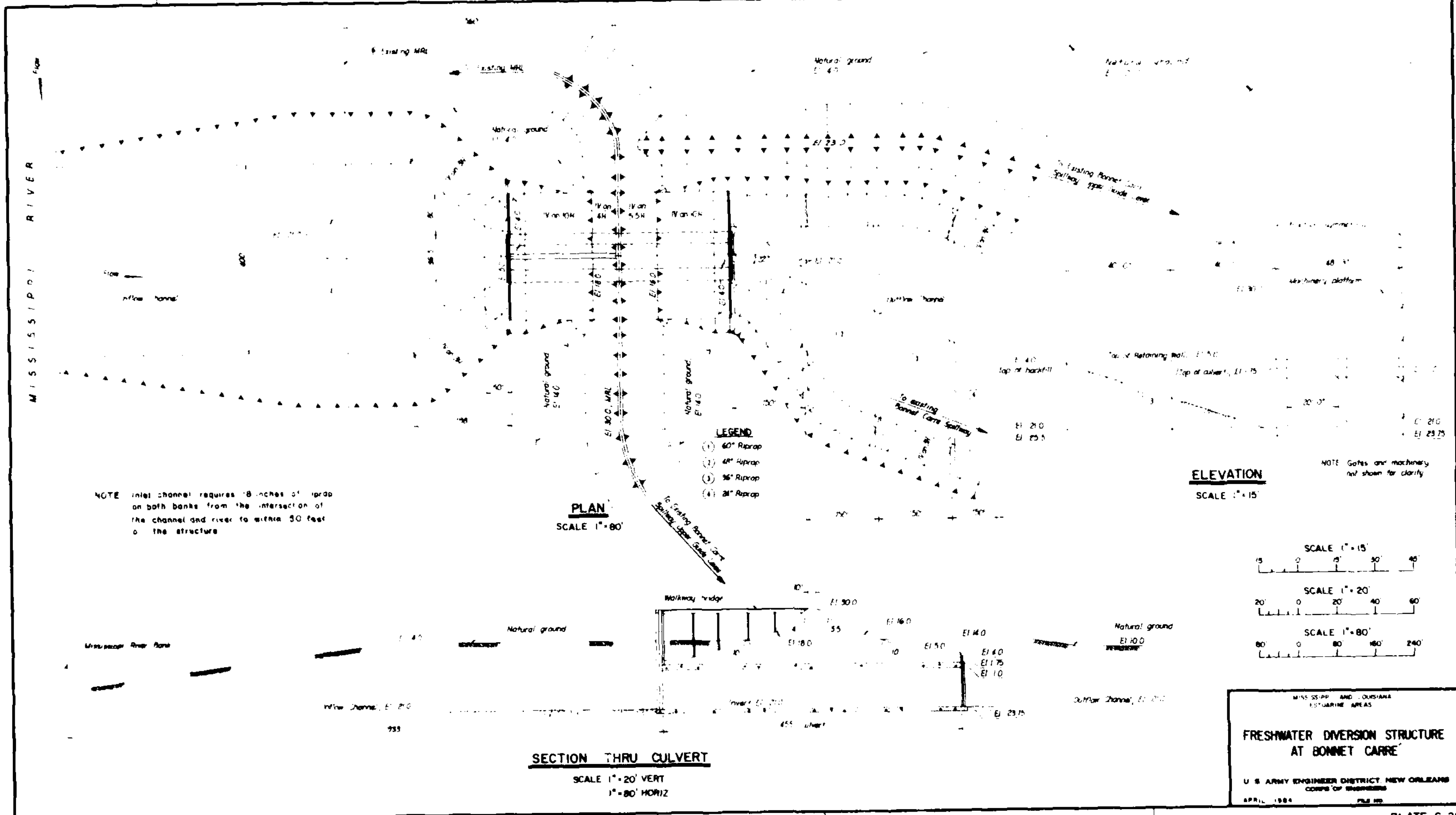
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

BORING 5-SCJU

US ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

PLATE C-28

2



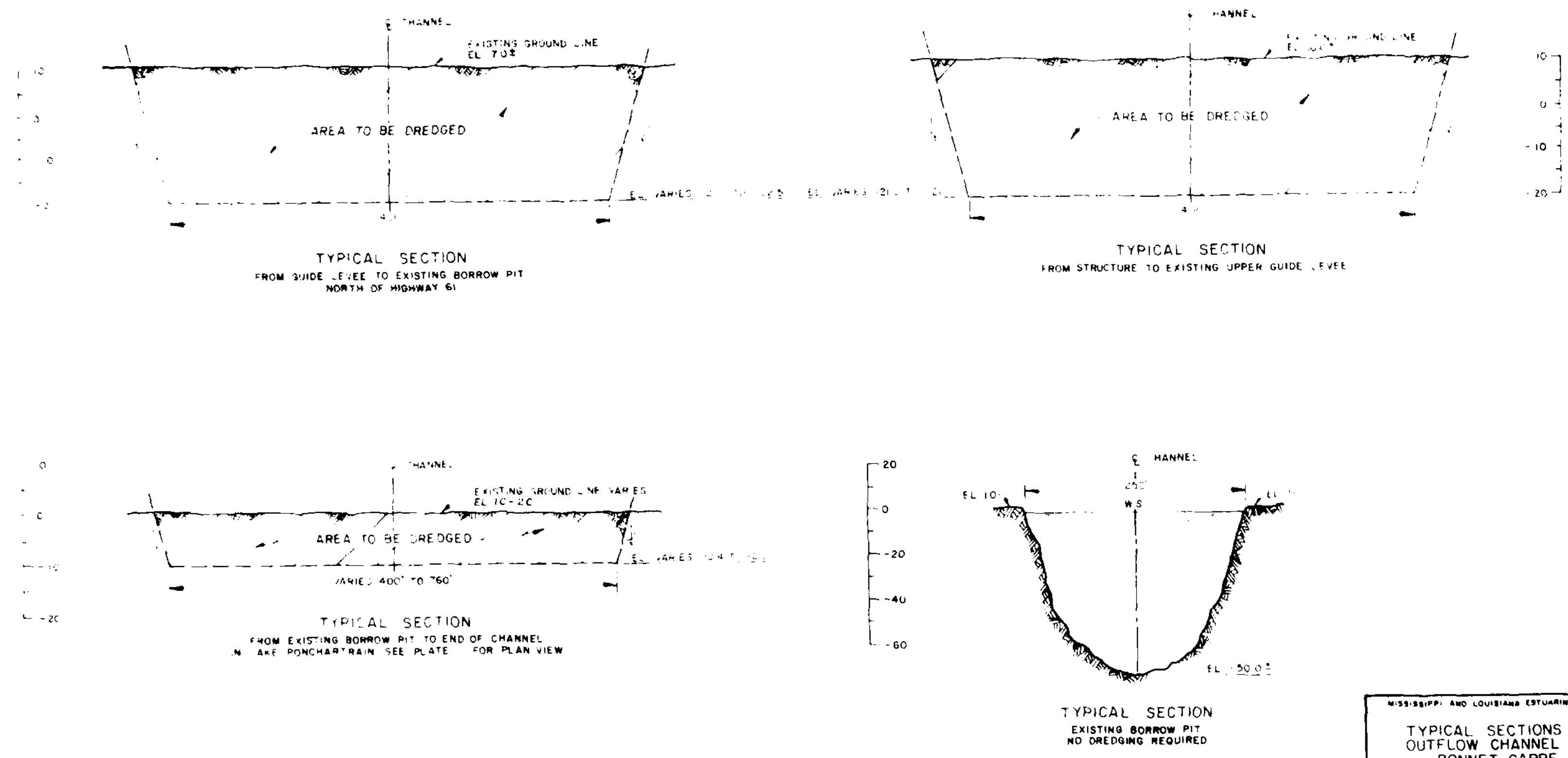
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

FRESHWATER DIVERSION STRUCTURE AT BONNET CARRE'

U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984

PLATE C-29



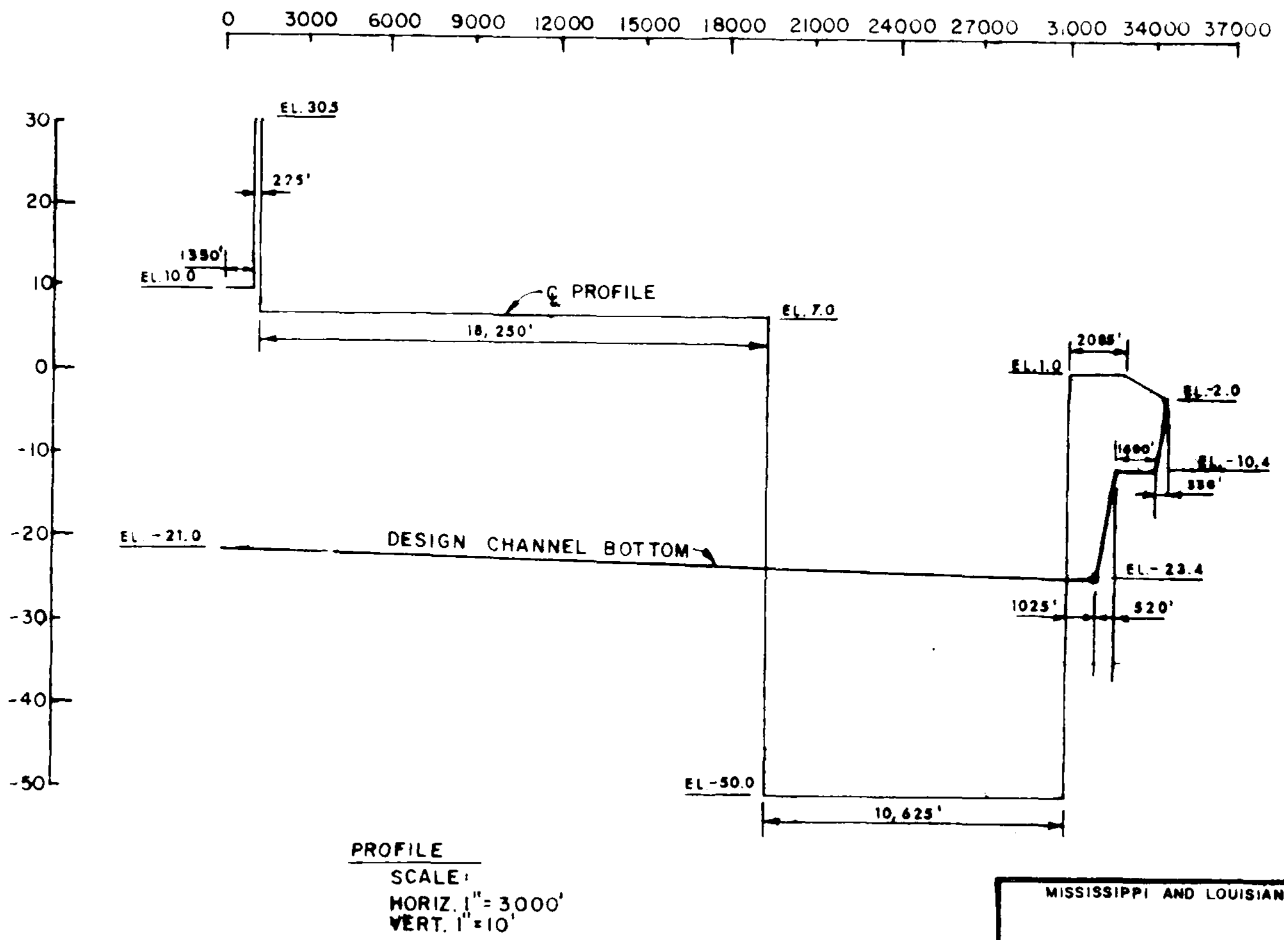
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

TYPICAL SECTIONS OF OUTFLOW CHANNEL AT BONNET CARRE DIVERSION SITE

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

PLATE C-30



MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

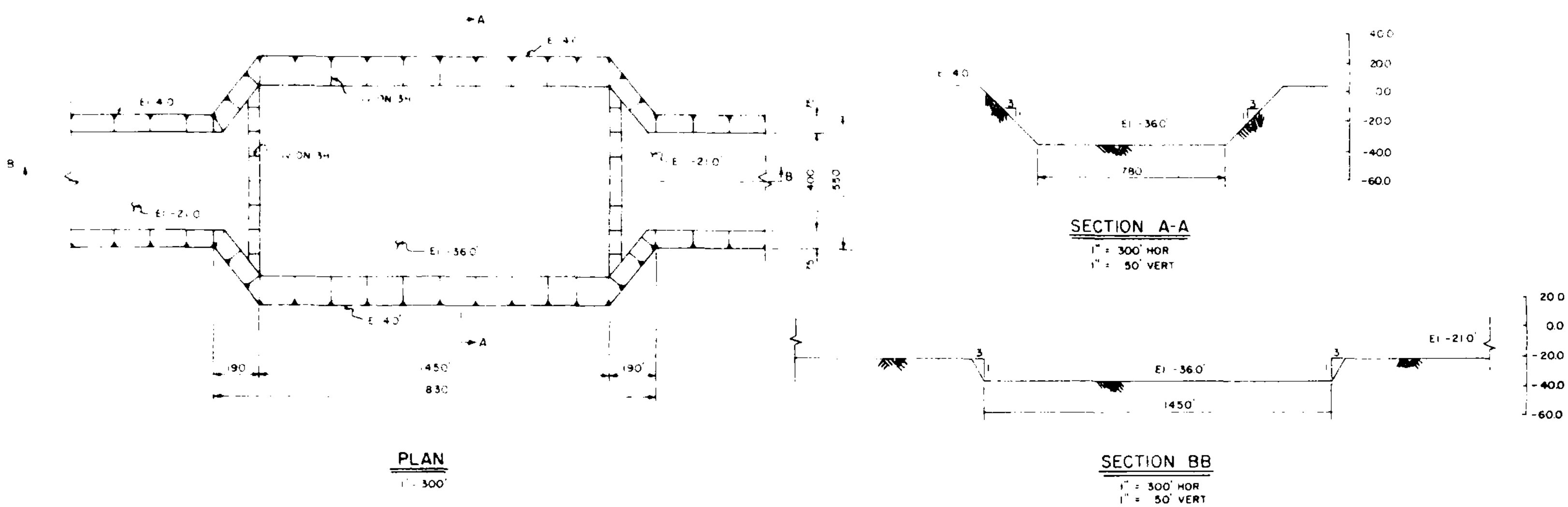
PROFILE OF CHANNEL BOTTOM

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

APRIL 1984 FILE NO.

PLATE C-31

PLATE C-31



SEDIMENTATION TRAP

APRIL

PLATE C-34

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Southeast Region
9450 Koger Boulevard
St. Petersburg, FL 33702

June 18, 1981 F/SER64:DLP

Mr. James F. Roy
Chief, Planning Division
New Orleans District, U. S. Corps of Engineers
P. O. Box 60267
New Orleans, LA 70160

Dear Mr. Roy:

This is in response to your letter of June 8, 1981, which requested information about species which are listed or proposed to be listed as provided by the Endangered Species Act. Your area of interest is a proposed project for freshwater diversion from the Mississippi River into Lakes Maurepas, Pontchartrain and Borgne, and Mississippi Sound, Mississippi and Louisiana.

We have reviewed the proposed project and have determined that no species of listed sea turtles or whales are likely to occur in the proposed project area. This concludes consultation responsibilities under Section 7 of the Endangered Species Act of 1973. However, consultation should be reinitiated if new information reveals impacts of the identified activity that may effect listed species or their critical habitat, a new species is listed, the identified activity is subsequently modified, or critical habitat determined that may be effected by the proposed activity.

Sincerely yours,

D. R. Ekberg

D. R. Ekberg
Chief, Environmental and Technical
Services Division

cc:
FWS, Atlanta, GA
FWS, Jackson, MS

IN REPLY REFER TO
LMNPD-RE

8 June 1981

Mr. Harold Allen
Acting Regional Director
National Marine Fisheries Service
9450 Koger Blvd.
St. Petersburg, FL 33702

Dear Mr. Allen:

In compliance with Section 7(c) of the Endangered Species Act Amendments of 1978, we are requesting information with respect to the threatened and/or endangered species in the study area for the study "Mississippi and Louisiana Estuarine Areas, Freshwater Diversion into Lakes Maurepas, Pontchartrain and Borgne, and Mississippi Sound." The purposes of the proposed work include improvement of wildlife and fisheries production, reduction of saltwater intrusion, enhancement of vegetative growth, and restoration of coastal wetlands.

This office requests a list of threatened and endangered species that may be affected by this project. Please include any species under consideration, but not yet formally listed.

A project description with attached location maps of the various features of the proposed project is inclosed.

Sincerely,

1 Incl
As stated

JAMES F. ROY
Chief, Planning Division

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
200 EAST PASCAGOULA STREET, SUITE 300
JACKSON, MISSISSIPPI 39201

June 18, 1981

IN REPLY REFER TO:
Log no. 4-3-81-150

Mr. James F. Roy
Department of the Army
New Orleans District
Corps of Engineers
P.O. Box 60267
New Orleans, Louisiana 70160

Dear Mr. Roy:

This pertains to your June 8, 1981 letter requesting endangered species information for the area of the study entitled: "Mississippi and Louisiana Estuarine Areas, Freshwater Diversion into Lakes Maurepas, Pontchartrain and Borgne, and Mississippi Sound."

A review of our data reveals that there are no endangered, threatened, or proposed species likely to be affected by this project. Although there is a nest of the bald eagle (*Haliaeetus leucocephalus*) in the general vicinity of Project Site A, the distance between this nest and the planned dredging activity is sufficient to suggest minimal impact on nesting eagles. Any reduction of the salinity of Lake Maurepas and the surrounding wetlands could actually prove beneficial to eagles nesting in the area.

If you require further information from our office concerning this project, please contact Fred Bagley of our staff, telephone number (601) 960-4912.

We appreciate your participation in the effort to protect endangered species.

Sincerely,

Dennis B. Jordan
acting for Gary L. Hickman
Area Manager

cc: RD, FWS, Atlanta, GA (ARD-FA/SE)
ES, FWS, Lafayette, LA
Department of Wildlife and Fisheries
New Orleans, LA

IN REPLY REFER TO
LMNPD-RE

8 June 1981

Mr. Gary Hickman
Area Manager
200 East Pascagoula Street
Jackson, MS 39201

Dear Mr. Hickman:

In compliance with Section 7(c) of the Endangered Species Act Amendments of 1978, we are requesting information with respect to the threatened and/or endangered species in the study area for the study "Mississippi and Louisiana Estuarine Areas, Freshwater Diversion into Lakes Maurepas, Pontchartrain and Borgne, and Mississippi Sound." The purposes of the proposed work include improvement of wildlife and fisheries production, reduction of saltwater intrusion, enhancement of vegetative growth, and restoration of coastal wetlands.

This office requests a list of threatened and endangered species that may be affected by this project. Please include any species under consideration, but not yet formally listed.

A project description with attached location maps of the various features of the proposed project is inclosed.

Sincerely,

1 Incl
As stated

JAMES F. ROY
Chief, Planning Division

Section 2. CORRESPONDENCE CONCERNING THREATENED AND ENDANGERED SPECIES

D.2.1. This section includes copies of correspondence between the US Army Corps of Engineers, New Orleans District, and the US Fish and Wildlife Service and National Marine Fisheries Service concerning the species present in the study area and the impacts of the proposed project on these species. Based on this correspondence, it has been determined that it is not necessary to prepare a Biological Assessment of Threatened and Endangered Species.

LITERATURE CITED

Correll, D.S., and M.C. Johnston. 1970. Manual of the Vascular Plants of Texas. Texas Research Foundation, Renner.

Fernald, M.L. 1950. Gray's Manual of Botany. American Book Co., ed. 8, New York.

Gleason, H.A., 1968. The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada. Hafner Publishing Co., New York.

Hitchcock, A.S. 1950. Manual of the Grasses of the United States. US Government Printing Office, Washington.

Lasseigne, A. 1973. Louisiana Legumes. Southwestern Studies, University of Southwestern Louisiana, Lafayette.

Montz, G.N. 1975a. Master List of Herbs, Fern and Fern Allies, and Vines of the New Orleans District. US Army Corps of Engineers, New Orleans, mimeograph report, 72 pp.

Montz, G.N. 1975b. Master List of Trees and Shrubs of the New Orleans District. US Army Corps of Engineers, New Orleans, mimeograph report, 30 pp.

Radford, A.E., H.E. Ahles, and C.R. Bell. 1968. Manual of the Vascular Flora of the Carolinas. University North Carolina Press, Chapel Hill.

Small, J.K. 1933. Manual of the Southeastern Flora. University North Carolina Press, Chapel Hill.

Sea-lavender	*Limonium* spp.
Shoalgrass	*Halodule beaudettei*
Smartweed	*Polygonum* spp.
Softstem bulrush	*Scirpus validus*
Southern-blue flag	*Iris virginica*
Southern naiad	*Najas quadalupensis*
Squarestem spikerush	*Eleocharis quadrangulata*
Spiderlily	*Hymenocallis occidentalis*
Swamp lily	*Crinum americanum*
Sweetgum	*Liquidambar styraciflua*
Sycamore	*Platanus occidentalis*
Three-cornered grass	*Scirpus olneyi*
Titi	*Cyrilla racemiflora*
Trumpet creeper	*Campsis radicans*
Tupelogum	*Nyssa aquatica*
Turtlegrass	*Thalassia testudinum*
Virginia creeper	*Parthenocissus quinquefolia*
Virginia willow	*Itea virginica*
Walter's millet	*Echinocloa walteri*
Water elm	*Planera aquatica*
Water hyacinth	*Eichhornia crassipes*
Water hyssop	*Bacopa monnieri*
Watermeal	*Wolffia* spp.
Water oak	*Quercus nigra*
Water paspalum	*Paspalum fluitans*
Waxmyrtle	*Myrica cerifera*
Widgeongrass	*Ruppia maritima*
Wildcelery	*Vallisneria americana*
Wild millet	*Echinochloa crusgalli*
Wildrice	*Zizania aquatica*
Wiregrass	*Spartina patens*

Gulf spikerush	*Eleocharis cellulosa*
Hackberry	*Celtis laevigata*
Hogcane	*Spartina cynosuroides*
Honeylocust	*Gleditsia triacanthos*
Ladies eardrops	*Brunnichia cirrhosa*
Leafy threesquare	*Scirpus robustus*
Live oak	*Quercus virginiana*
Lizard's tail	*Saururus cernuus*
Maidencane	*Panicum hemitomon*
Manateegrass	*Cymodacea filiformis*
Marsh boltonia	*Boltonia asteropides*
Marsh elder	*Iva frutescens*
Mayhaw	*Crataegus opaca*
Nuttall oak	*Quercus nuttalii*
Overcup oak	*Quercus lyrata*
Oystergrass	*Spartina alterniflora*
Palmetto	*Sabal minor*
Pennywort	*Hydrocotyl* spp.
Peppervine	*Ampelopsis arborea*
Pickerelweed	*Pontederia cordata*
Poison ivy	*Rhus radicans*
Pumpkin ash	*Fraxinus tomentosa*
Rattan vine	*Berchemia scandens*
Rattlebox	*Daubentonia drummundii*
Red bay	*Persea borbonia*
Red maple	*Acer rubrum*
Roseau	*Phragmites australis*
Royal fern	*Osmunda regalis*
Saltgrass	*Distichlis spicata*
Saltmarsh lythrum	*Lythrum linaere*
Saltmarsh morning glory	*Ipomea sagittata*
Saltwort	*Batis maritima*
Sawgrass	*Cladium jamaicense*

LIST OF COMMON AND SCIENTIFIC NAMES OF PLANTS

Alligatorweed	*Alternanthera philoxeroides*
American elm	*Ulmus americana*
Baldcypress	*Taxodium distichum*
Blackgum	*Nyssa sylvatica*
Black mangrove	*Avicennia germinans*
Black rush	*Juncus roemerianus*
Black willow	*Salix nigra*
Blunt spikerush	*Eleocharis obtusa*
Bulltongue	*Sagittaria falcata*
Bullwhip	*Scirpus californicus*
Buttonbush	*Cephalanthus occidentalis*
Carolina ash	*Fraxinus caroliniana*
Cattail	*Typha* spp.
Cottonwood	*Populus deltoides*
Cross vine	*Anisostichus capreolatus*
Cutleaf mermaidweed	*Proserpinaca pectinata*
Cyperus	*Cyperus* spp.
Deciduous holly	*Ilex decidua*
Deerpea	*Vigna luteola*
Drummond red maple	*Acer drummondii*
Duckweed	*Lemna* spp.
Dwarf spikerush	*Eleocharis parvula*
Eastern baccharis	*Baccharis halimifolia*
Elderberry	*Sambucus canadensis*
Frogbit	*Limnobium spongia*
Glasswort	*Salicornia* spp.
Great duckweed	*Spirodela polyrhiza*
Green ash	*Fraxinus pennsylvanica*
Greenbriars	*Smilax* spp.
Green hawthorn	*Crataegus viridis*

Section 1. LIST OF COMMON AND SCIENTIFIC NAMES OF PLANTS

D.1.1. This section contains an alphabetized list of the common names of plants discussed in the report with corresponding scientific names. The list is taken from Montz (1975a, 1975b) who used the following taxonomic sources: Correll and Johnston (1970); Fernald (1950); Gleason (1968); Hitchcock (1950); Lasseigne (1973); Radford, Ahles, and Bell (1968); and Small (1933).

MISSISSIPPI AND LOUISIANA ESTAURINE AREAS STUDY

Report on Freshwater Diversion
to the
Lake Pontchartrain Basin and Mississippi Sound

Appendix D

N A T U R A L R E S O U R C E S

D.0.1. This appendix contains technical information and methodologies concerning the natural resources of the study area. The appendix consists of six separate sections. Section 1 contains an alphabetized list of common names of plants discussed in the report with corresponding scientific names. Section 2 contains correspondence concerning endangered species. Section 3 contains information concerning habitat acreages that would be affected within the construction rights-of-way for the proposed project. Section 4 contains information concerning methodologies used for estimating with- and without-project habitat acreages for the Louisiana and Mississippi portions of the study area. Section 5 contains an explanation of the methodologies and concepts used for predicting with-project oyster production in Louisiana and Mississippi. Section 6 consists of the final Fish and Wildlife Coordination Act Report.

LIST OF TABLES

LIST OF EXHIBITS

LIST OF PLATES

TABLE OF CONTENTS

APPENDIX D

NATURAL RESOURCES

Section 3. HABITAT ACREAGE AFFECTED BY CONSTRUCTION OF THE BONNET CARRE' SITE

D.3.1. This section contains information concerning the acreage that would be affected by construction of the Bonnet Carre' site. All acreages used in this section are based on designs and information contained in Appendix C, Engineering Investigations.

D.3.2. The section is presented in two parts. The first part identifies the methodology used to identify and delineate the acreages involved. The second part provides a more detailed analysis of the acreages and habitats affected by direct construction.

METHODOLOGY USED TO DETERMINE HABITAT ACREAGE AFFECTED BY CONSTRUCTION OF THE DIVERSION ROUTES

D.3.3. In order to determine impacts due to direct construction of the freshwater diversion route, it was necessary to identify the acreages and quantify the habitat types that would be altered. The rights-of-way necessary for the site was drawn on a 1:24,000 US Geological Survey quandrangle map based on information contained in Appendix C, Engineering Investigations. The acreages of the various habitat types were determined from analysis of the quandrangle maps, 1978 high altitude infrared photos, and US Fish and Wildlife Service habitat maps. Field verification of the various habitat types was limited due to high water resulting from the 1983 spillway opening. The results of this analysis are presented in tables D-3-1 and D-3-2.

TABLE D-3-1

TOTAL IMPACTS OF DIVERSION ROUTE CONSTRUCTION
BONNET CARRE' PLAN

Habitat Types
(Acres)

Wooded Swamp	Scrub Shrub	Open Water	Developed	Total
618	56	63	1,074	1,811

TABLE D-3-2

ANALYSIS OF CONSTRUCTION IMPACTS BY PROJECT REACH

	Habitat Types (Acres)			
Reach	Wooded Swamp	Scrub Shrub	Open Water	Developed
End of outfall channel to lakefront			35	
Lakefront to borrow pit	146		1	
South end of borrow pit to Airline Hwy	448			51
Airline Hwy to upper guide levee	24	56	27	971
Structure to guide Levee				37
Structure				5
Mississippi River guide levee				4
Hwy 628 relocation				6
TOTALS	618	56	63	1074

DETAILED ANALYSIS OF HABITAT ACREAGE

D.3.4. The following is a description of acreage affected by the specific construction activity within the reach indicated.

End of outfall channel to Lakefront

Channel:	10 acres open water
Disposal:	25 acres open water

Lakefront to borrow pit

Channel:	1 acre open water
	33 acres wooded swamp
Disposal:	113 acres wooded swamp

South end of borrow pit to Airline Hwy

Channel:	73 acres wooded swamp
Disposal:	51 acres acres developed
	375 acres wooded swamp

Airline Hwy to upper guide levee

Channel:	96 acres developed
	27 acres open water
	24 acres wooded swamp
	35 acres scrub shrub
Disposal:	875 acres developed
	21 acres scrub shrub

Structure site to guide levee

Channel: 37 acres developed

Structure: 5 acres developed

Mississippi River levee guide

Channel: 4 acres developed

Hwy 628 relocation

Channel: 6 acres developed

Section 4. METHODOLOGIES FOR ESTIMATING HABITAT CHANGES IN THE STUDY AREA

D.4.1. This section describes methodologies used for estimating the without- and with-project habitat acreages through year 2040 in the Louisiana and Mississippi portions of the study area. Examples of the calculations are included as well as tables demonstrating with-project and without-project habitat changes over the project life.

D.4.2. In order to assess project impacts on the study area, acreages were projected for the various habitat types in the project area under both with-project and without-project conditions. The base year used for habitat acreages was 1978. Because all habitat types in the project area are changing due to development, drainage projects, subsidence, saltwater intrusion, and a number of other factors, it was necessary to establish rates of change and to predict acreages under future without-project (FWOP) conditions.

D.4.3. Habitat maps and other information from the "Mississippi Deltaic Plain Region (MDPR) Ecological Characterization: A Habitat Mapping Study" (Wicker 1980) were used to calculate the FWOP habitat change rates and future habitat acreages. That study identified and measured habitats in the entire coastal zone of Mississippi and a large portion of Louisiana's coastal zone and included all of the study area. Hydrologic Unit I and portions of Unit II of the MDPR comprise the study area. Hydrologic Unit I extends from the Mississippi-Alabama border to the Louisiana-Mississippi border and includes all areas in the coastal zone below 5 feet in elevation. Hydrologic Unit II extends from the Mississippi-Louisiana border to the eastern bank of the Mississippi River from near Donaldsonville southeastward to Baptiste Collette Bayou. However, the area south of Louisiana Highway 46 and west of the Mississippi River Gulf Outlet MR-GO is not included in the study area.

The Pontchartrain Basin, Chandeleur Sound, and the Chandeleur Islands are included in the study area. The inland boundary of the unit is the Coastal Zone Management Boundary. Two sets of 1:24,000 habitat maps were prepared for the MDPR study, one set for 1955-56 and one for 1978. The habitat acreages on these maps were measured using an electronic digitizer. US Fish and Wildlife Service (FWS) and Corps of Engineers (CE) biologists utilized the information to predict the rate of change for selected habitats between the mid-1950's and 1978. The rate was then projected for the period 1990 to 2040.

D.4.4. Major habitat types in the study area are fresh/intermediate marsh (F/IM), brackish marsh (BM), saline marsh (SM), bottomland hardwood forest (BLH), wooded swamp (WS), estuarine water bodies, fresh water bodies and developed lands. Habitat acreage projections were limited to the vegetated wetlands, since only those habitat acreages would be significantly affected by the project. Although fresh and estuarine water bodies would be affected by the project, the effects would be largely qualitative. In projecting habitat acreages for future conditions, the study area was divided into Mississippi and Louisiana portions, since vegetated wetland changes resulting from project implementation would be limited to the Louisiana portion.

MISSISSIPPI PORTION OF THE STUDY AREA

D.4.5. Average annual habitat change rates were computed for the vegetated wetlands for the 22-year period (1955-56 to 1978). Fresh marsh (FM) acreage declined at a rate of 2.10% annually, intermediate marsh (IM) at 0.27%, BM at 0.18%, SM at 0.23%, and BLH at 0.15%. The rate of change for WS was so low (0.04%) that the WS acreage was considered stable. Examples of the equations used to calculate habitat change rates and future habitat acreage are presented below:

Fresh Marsh: There was a loss of 3,000 acres between 1955-56 (6,500 acres) and 1978 (3,500 acres). The average annual acres lost was divided by the 1955-56 acreage to determine the annual rate of change:

6,500 acres - 3,500 acres = 3,000 acres lost

$$\frac{3,000}{22 \text{ years}} = 136 \text{ acres lost per year}$$

$$\frac{136}{6,500 \text{ acres}} = 0.0210 \text{ (annual rate of change)}$$

The equation used to predict habitat acreages for future years was:

$$\text{acres } FM_{n+1} = FM_n \times (1-0.0210)$$

where,

n = any given year and
n + 1 = given year plus 1.

D.4.6. The 1978 acreages, as well as the acreages projected for target years over the project life, are listed in table D-4-1 by habitat type. The FM and IM habitat types were combined to form the F/IM habitat type, due to their similar habitat values. Wetland acreages in this portion of the study area would be the same under FWP and FWOP conditions since the proposed diversion would only alter water salinities in the extreme western part of Mississippi Sound. Futhermore, the salinities in this area are influenced primarily by Pearl River and Mississippi Sound hydrological conditions. The remainder of the wetlands in the Mississippi coastal zone would not be affected by the proposed diversion.

TABLE D-4-1

COMPARISON OF HABITAT TYPES WITH AND WITHOUT PROJECT-MISSISSIPPI 1/
(Acres)

Habitat Type	1978 W 2/	1978 W/O 3/	1990 W	1990 W/O	2000 W	2000 W/O	2010 W	2010 W/O	2020 W	2020 W/O	2030 W	2030 W/O	2040 W	2040 W/O
Bottomland Hardwoods	42,394	42,394	41,637	41,637	41,017	41,017	40,406	40,406	39,804	39,804	39,210	39,210	38,626	38,626
Wooded Swamp 4/	33,162	33,162	33,162	33,162	33,162	33,162	33,162	33,162	33,162	33,162	33,162	33,162	33,162	33,162
Fresh Intermediate Marsh	19,885	19,885	18,575	18,575	17,633	17,633	16,802	16,802	16,061	16,061	15,397	15,397	14,795	14,795
Brackish Marsh	19,942	19,942	19,515	19,515	19,167	19,167	18,825	18,825	18,489	18,489	18,159	18,159	17,834	17,834
Saline Marsh	27,325	27,325	26,580	26,580	25,975	25,975	25,384	25,384	24,806	24,806	24,241	24,241	23,690	23,690
Total Marsh	67,152	67,152	64,670	64,670	62,775	62,775	61,011	61,011	59,356	59,356	57,797	57,797	56,319	56,319

1/ No reductions in rates of habitat losses have been claimed in Mississippi. Therefore, with and without project acreages were assumed the same.
2/ With Project
3/ Without Project
4/ Loss rate negligible

FUTURE WITHOUT-PROJECT CONDITIONS

D.4.7. Wetlands in this portion of the study area have changed considerably during the 22-year period studied by Wicker (1980). A significant contributing factor was construction of the MR-GO which allowed greatly increased salinities in Lakes Borgne and Pontchartrain and adjacent marshes and water bodies. Construction of the ship channel was initiated in 1958 and completed in 1965. The most pronounced changes occurred in St. Bernard Parish where 10,100 acres of WS and virtually all 20,200 acres of FM were lost over the 22-year period (Wicker, 1980). In the Lake Pontchartrain area saltwater intrusion was responsible in part for conversion of low salinity marshes to more brackish types and of WS to marsh along the western shore of Lake Pontchartrain. In 1973 and 1975, near the end of the 22-year period, flood conditions required operation of the Bonnet Carre' Spillway. The freshened conditions resulted in a change to fresher marsh types in the vicinity of eastern Lake Pontchartrain and northern Lake Borgne (Chabreck and Linscombe, 1982). The influence of the MR-GO construction on the trend toward increased salinities has somewhat stabilized and the existing salinity regime is not expected to change significantly during the project life. Correspondingly, the wetland changes measured for the 22-year period would be unsuitable for computing FWOP change rates for this study because of the atypical hydrological changes which occurred during the period of measurement and because of the predicted salinity regime stabilization. Two basic assumptions were used in developing the methodology for FWOP changes. Since salinity increases in the study area have stabilized somewhat, the first assumption was that marsh boundaries would also be stable, i.e., further shifts in marsh boundaries would not occur. The second assumption involved the natural deterioration which occurs in deltaic marshes. Measurements of marsh areas within stable boundaries over the

22-year period were used to determine rates of change for marshes not affected by major salinity changes. These rates were assumed to be representative of marshes undergoing changes due to natural processes (subsidence and erosion) and were applied to present marsh acreages.

D.4.8. FM and IM were combined to form the F/IM type. FM and IM are located in the low salinity zones in the study area. The largest zones include the mouth of Pearl River, Pass Manchac area, and the area east of Bonnet Carre' Spillway. Rates of loss for only FM in these areas were determined, as IM was not specifically delineated on the 1955-56 habitat maps. It was assumed that IM would occur in the same proportion as FM and have the same loss rate.

D.4.9. The marsh loss rate for the F/IM in the Pearl River area was determined by measuring an area on the habitat maps corresponding with the Rigolets 7.5 minute USGS quadrangle which was FM in 1955-56 and 1978. In 1955-56, 7,920 acres of marsh was present, while in 1978 the marsh acreage had been reduced to 7,270 acres. By using the same type of calculations illustrated for the Mississippi portion, the average annual marsh loss rate was computed to be 0.40%.

D.4.10. The marsh loss rate for the F/IM in the Pass Manchac area was determined by measuring a 1,320 marsh area on the habitat maps corresponding with the Pontchatoula S.E. 7.5 minute USGS quadrangle. The area measured was representative of FM conditions in this vicinity. The average annual marsh loss rate was computed to be 0.40%.

D.4.11. The marsh loss rate for the F/IM east of Bonnet Carre' Spillway was determined by using the measured marsh acreages on habitats maps corresponding to the Luling 1:24,000 USGS quadrangle. In 1955-56, 24,000 acres of FM existed. The average annual marsh loss rate was computed to be 2.10%.

D.4.12. To compensate for the differences in the loss rates, the rates were weighted proportionally to the areas covered. In 1978, 32,970 acres of FM existed in the Louisiana portion of the study area (Wicker, 1980). Using only the information readily available, it was determined that 95% of the total FM acreage (31,339) could be segregated by site. FM comprised 15,000 acres in the Pearl River area or 48% of the 31,339 acres, 12,500 acres (40%) in the Pass Manchac areas, and 3,839 acres (12%) in the Bonnet Carre Spillway area. The weighted loss rate for FM was computed by multiplying the proportion of the total for each area by the rate of change for the respective area as shown below:

Area	% of Total	Loss Rate		Weighted Loss Rate (% year)
Pearl River	48	0.0040	=	0.19
Pass Manchac	40	0.0040	=	0.16
Bonnet Carre'	12	0.0210	=	0.25
Total				0.60

D.4.13. Thus, the average annual loss rate for FM was computed to be 0.60%. It was assumed that this loss rate would continue under FWOP conditions. In 1978, the F/IM acreage consisted of 58,347 acres and was used as a base from which FWOP projections were made. The formulas used in the computations are identical to those for the Mississippi portion of the study area. F/IM acreages by target year are listed in table D-4-2.

D.4.14. Most of the 137,662 acres of BM in the Louisiana portion of the study area is located adjacent to Lake ɔrgne. Small portions of brackish marsh are present along the northeastern and southwestern shores of Lake Pontchartrain. To determine the loss rate for BM, habitat maps based on 1:24,000 quadrangles were selected for the area

TABLE D-4-2

COMPARISON OF HABITAT TYPES WITH AND WITHOUT PROJECT-LOUISIANA
(Acres)

Habitat Type	1978 W[1]	1978 W/O[2]	1990 W	1990 W/O	2000 W	2000 W/O	2010 W	2010 W/O	2020 W	2020 W/O	2030 W	2030 W/O	2040 W	2040 W/O
Bottomland Hardwoods[3]	48,338	48,338	45,516	45,516	43,291	43,291	41,174	41,174	39,161	39,161	37,247	37,247	35,426	35,426
Wooded Swamp	155,507	155,507	133,071	133,071	118,488	116,868	105,681	102,638	94,433	90,140	84,555	79,164	75,880	69,525
Fresh Intermediate Marsh	58,346	58,346	54,282	54,282	55,513	51,111	52,646	48,126	49,944	45,315	47,400	42,668	45,001	40,177
Brackish Marsh	137,662	137,662	129,626	129,626	119,740	123,298	114,496	117,261	109,508	111,528	104,763	106,075	100,251	100,889
Saline Marsh[4]	56,386	56,386	50,223	50,223	45,604	45,604	41,411	41,411	37,603	37,605	34,145	34,145	31,005	31,005
Total Marsh	252,394	252,394	234,131	234,131	220,857	220,003	208,553	206,798	197,055	194,446	186,308,	182,888	176,257	172,071

1/ With Project
2/ Without Project
3/ The project claims no quantified benefits to bottomland hardwoods. Therefore, with and without project acreages were assumed the same.
4/ The project claims no quantified benefits to saline marsh. Therefore, with and without project acreages were assumed the same.

which consisted of BM in 1955-56 and 1978 and which were not greatly influenced by the results of the MR-GO construction. Habitat maps for the Chef Menteur and Point au Marchettes quadrangles met these criteria. The two quadrangles contain about 30% (40,952) of the total BM acreage in this portion of the study area. The average annual BM loss rate for the 2 quadrangles was used as the rate of change for BM in projecting FWOP conditions. The rate of change was computed in the same manner as the wetland change rates of the Mississippi portion of the study area. The calculations showed that the BM average annual loss rate was 0.50%. The BM acreages by target year are listed in table D-4-2.

D.4.15. Essentially all of the SM in this portion of the study area is located in eastern St. Bernard Parish between Mississippi and Chandeleur Sounds. Marsh areas within SM boundaries in 1955-56 and 1978 and out of direct MR-GO influence were sought to determine SM rates of change for use in projecting FWOP conditions. The SM within the Three Mile Bay and Oak Mound Bayou 7.5 minute quadrangles met the criteria and comprises about 20% of the total SM acreage. The rate of change was computed in the same manner as the wetland change rates for the Mississippi portion of the study area. The calculations showed that the SM average annual loss rate was 0.96%. SM acreages by target year are listed in table D-4-2.

D.4.16. WS is primarily located from along the western shore of Lake Pontchartrain extending to near the western boundary of the study area. WS acreage decreased from 217,056 to 155,507 or 28% from 1955/56 to 1978. Drainage projects for residential, industrial, and agricultural development; transportation projects; oil and gas development; and the effects of saltwater intrusion and subsidence have resulted in the conversion of swamp to other land use types. It was assumed that the rate of change experienced over the 22-year period would continue as additional flood control and transportation projects

Yscloskey and Shell Beach as well as via Bayous La Loutre and St. Malo. Oysters survived in this area even during the 1973 and 19[illegible] flood years.

D.5.9. Once the salinity zones of oyster production were established, the acreage of suitable bottoms available within these zones was determined. This determination was made separately for the Louisiana and Mississippi portions of the study area. In Louisiana, both public and leased oyster bottoms occur, so it was necessary to determine the acreage of suitable bottom available in both categories. In the early 1970's, suitable, historically productive oyster bottoms on the public oyster grounds of Louisiana were quantified and mapped for LDWF by Captain Baldo Pausina, a local oyster fisherman considered to be the most knowledgeable person available concerning the reef sizes and locations. Corps of Engineers and LDWF biologists made several trips in 1982 to the general area to inspect the reefs and water bottoms to verify that large areas of suitable bottom exist for oyster production, provided desirable salinities are achieved.

D.5.10. Using Captain Pausina's map, approximately 8,000 acres of historically productive public reef areas were determined to lie within the zone of optimal production. It was assumed that 75 percent of this area (6,000 acres) would provide suitable substrate (bottom) for oyster production. Because the mapping effort was conducted 10 years ago, and to maintain a conservative posture in the analysis, production over the entire 8,000-acre area was not claimed. This estimate takes into account the possibility that some reefs may no longer be available as habitat. Using the area of 6,000 acres and a productivity factor of 20 oysters/m^2, with-project oyster production within the optimal zone on Louisiana's public grounds was derived as follows:

oyster production was determined by solving the regression equation for an oyster production level of 20 oysters/m^2. Although this zone is capable of producing greater than the 20 oysters/m^2 in some areas, it was decided to use 20 oysters/m^2 to represent good production to insure that the analysis is reasonable and conservative. Based on the regression equation, production could be obtained with an average monthly deviation of 2.8 ppt on either side of the annual mean isohaline (16 ppt). Acknowledging that this analysis is not finitely accurate, and for purposes of simplicity, the 2.8 ppt was rounded to 3.0 ppt. The 13 and 19 ppt isohalines were then plotted on the base map (plate D-1). The area encompassed by these isohalines was assumed capable of producing 20 commercially harvestable oysters per square meter of suitable bottom on the average of every other year. Zones of lesser production (secondary zones) were determined by computing the salinity range which would produce 0-20 oysters m^2, or an average of 10 oysters/m^2, by solving the regression equation for an oyster production level of 10 oysters/m^2. It was determined that this level of production could be obtained with an average monthly deviation of 4.0 ppt on either side of the annual mean isohaline (16 ppt). The 12 and 20 ppt isohalines were plotted on the base map (plate D-1). The areas between the 12-13 ppt isohalines and the 19-20 ppt isohalines were classified as the secondary zones of production capable of producing 10 commercially harvestable oysters per square meter of suitable bottom on the average of every other year. The preceding discussion was used to define the zones of production and were based on August salinities. The actual salinities which define the optimal and secondary zones vary on a monthly basis. Although some oyster production would occur outside of the above described zones, this condition has not been quantified in the analysis. The southern lobe of Lake Borgne between Proctor Point and Pointe aux Marchettes is such an area. Oyster production in this area would probably occur even under the with-project condition. This area is not likely to be over freshened by the project. Sufficient salt water enters this area from the MRGO via several channels due east of

freshwater diversion structure would provide supplemental freshwater which is no longer available from seasonal Mississippi River flooding. The supplemental flows in cubic feet per second (cfs) for which the diversion structure is designed at the Bonnet Carre' site are as follows:

MONTH	FLOW (CFS)	Mean Optimal Allowable Salinity at Location #2	Mean With-Project Salinity at Location #2
January	-	15-17	14.2
February	-	13-15	12.2
March	10,800	11-13	9.6
April	30,000	7-9	8.0
May	16,700	6-8	8.0
June	14,600	12-14	12.5
July	3,200	12.5-13.5	13.0
August	2,600	15-17	16.0
September	2,000	16-18	17.0
October	5,500	16-18	17.0
November	3,200	15-17	16.0
December	-	15.5-16.5	16.0

D.5.8. The with-project 15 ppt isohaline for the month of August closely approximates the position of the optimal salinity line at Location #2. The desirable salinity at this location in August, as identified in the LDWF study, is 15.7 ppt, or approximately 16 ppt. The August isohaline was adjusted to represent 16.0 ppt and this line was plotted on a base map of the study area (plate D-1). In order to establish a zone of optimal oyster production (optimal zone), the salinity range which would provide suitable conditions for high seed

the oyster drill, xanthid and portunid crabs, predaceous polychaetes, and boring gastropods, as well as many of the fouling organisms which inhibit oyster set, including boring and encrusting sponges, barnacles, bryozoans, and algae. The freshening effect on the average of every other year would allow the oysters to grow in size and shell thickness, making them less vulnerable to many of the less notable, yet significant, predators. The oyster drill, although capable of preying on large oysters, does not generally appear in large numbers unless several dry, highly saline years occur in sequence. It is believed that if large quantities of seed oysters are produced on the average of every 2 to 3 years, the oyster industry will flourish.

D.5.7. The mean monthly salinities determined to be optimal by the LDWF study are shown below:

MONTH	MEAN OPTIMUM SALINITY (PPT)	STANDARD ERROR (±)
January	16.4	1.04
February	14.4	0.79
March	11.6	1.02
April	8.0	1.27
May	7.0	0.92
June	12.5	0.80
July	12.7	0.57
August	15.7	0.80
September	17.0	1.06
October	16.8	0.87
November	16.1	0.82
December	15.7	0.52

In order to achieve the desired mean monthly salinities at Location #2 shown on plate B-5 of the Plan Formulation appendix (Appendix B), the EA

relationships between each of the variables indicated that salinity during the year in which spatfall occurred was closely related to production of seed oysters the following year. The optimal salinity regime was derived from data associated with good oyster production. Good production was considered to be 20 or greater seed oysters per square meter of suitable bottom (>20 oysters/m^2). A regression equation was derived to express the relationship between salinity and oyster production [Seed production = - 43.89 + 2,144.5 (Σ monthly deviations from the optimum regime $^{-1}$)].

D.5.4. Based on the LDWF study, the critical months in terms of the optimal salinity regime for oyster production appear to be May through September. Optimal salinities in May range from 6.0 to 8.0 parts per thousand (ppt). Salinities should average 13.0 ppt in June and July and not increase above 15.0 ppt until late August. September salinities should not exceed an average of 20.0 ppt. The critical factor relative to salinity and oyster production appears to be a spring freshening effect similar to that which occurred when the Mississippi River overflowed its banks in the spring. The freshening apparently controls many of the organisms which prey on and compete with oysters.

D.5.5. The diversion plan recommended has been designed to maintain the optimal monthly salinities identified in the LDWF study over the historically productive bottoms in the study area. This plan has been reviewed and recommended by an interagency Ad Hoc Group in June 1982. The diversion structure has been designed to provide sufficient supplemental fresh water to achieve the optimal salinity regime on the average of every other year (the dryest year out of two, or a 50% drought condition). The projected with-project isohalines are presented in Appendix C, Engineering Investigations.

D.5.6. The diversion criteria for which the project is design would eliminate or reduce populations of many of the oyster predators such as

Section 5. METHODOLOGY USED FOR ESTIMATING WITH-PROJECT OYSTER BENEFITS

D.5.1. This section explains the assumptions and methodology used for estimating with-project oyster benefits attributable to implementation of the Mississippi and Louisiana Estuarine Areas (MLEA) freshwater diversion project. These benefits would accrue from restoring optimal salinity conditions over large areas of prime, historically productive oyster bottoms in the western portion of Mississippi Sound and the Louisiana marshes east of the Mississippi River - Gulf Outlet (MRGO). Discussions concerning historical oyster production and the changes which have resulted in a declining oyster industry in the study area are presented in Appendix A, Problem Identification. The assumptions and methodology described in this section were developed through numerous meetings with individuals knowledgeable in the field of oyster biology and the oyster industry and included personnel from the Corps of Engineers (CE), US Fish and Wildlife Service (USFWS), Louisiana Department of Wildlife and Fisheries (LDWF), Mississippi Bureau of Marine Resources (MBMR), and the Gulf Coast Research Laboratory (GCRL) in Ocean Springs, Mississippi.

D.5.2. The methodology employed to ascertain with-project oyster production was made possible largely due to a recently completed study by the LDWF. The results of the LDWF study are presented in a paper entitled "Optimum Salinity Regime for Oyster Production on Louisiana's State Seed Grounds." The paper was authored by Mark Chatry, Ronald J. Dugas, and Kirk A. Easley. The paper was published in the noted journal Contributions in Marine Science, University of Texas, in Volume 26 in September 1983. A copy of this paper is presented in Exhibit A of this appendix.

D.5.3. The LDWF study investigated salinity, spatfall (setting of oyster larvae), and seed oyster production from sampling stations on Louisiana's prime seed grounds using data collected from 1971-1981. The

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1991 - 2000 = acres lost under FWOP conditions

133,071 - 116,868 = 16,203 acres

16,203 x 0.90 = 14,583 acres lost under FWP conditions

The FWP acreage lost was then subtracted from the 1991 acreage as shown below:

133,071 - 14,583 = 118,488 acres remaining in 2000 under FWP conditions

Acreages for other years were computed in the same manner and the results are shown on table D-4-2.

Saline Marsh

D.4.24. As stated earlier, no change from FWOP acreages was projected for SM. Therefore, FWP acreages equal FWOP acreages and are shown on table D-4-2.

Bottomland Hardwoods

D.4.25. Freshwater diversion was assumed to have no impact on BLH loss rates as BLH have been and are expected to continue to be cleared for conversion to various higher land use types such as residential, industrial, agricultural, and transportation. Thus BLH acreages under FWP conditions would equal the respective acreages under FWOP conditions. These acreages are shown on table D-4-2.

Wooded Swamp

D.4.26. Since maximum annual with-project salinities would be reduced to less than 2 ppt, conversion of WS to F/IM was projected to cease. WS acreage would continue to be reduced by saltwater intrusion and other factors at an unknown rate. However, it is known that the rate of saltwater intrusion would not be as rapid as that which resulted in the years following MR-GO construction. Therefore, it was assumed that saltwater intrusion would be responsible for 10% of the total loss; thus, under FWP conditions the loss rate wold be reduced by 10%. FWOP acreages for 1990 through 2040 were used in calculating FWP acreages. As with F/IM and BM, it was assumed that the reduced losses would be evident in 1991. To compute the acreage for 2000 , the 2000 FWOP acreage was subtracted from 1991 FWOP acreage and the difference multiplied by the reciprocal of 0.10 (0.90) to account for the project induced 10% reduction in loss.

D.4.23. Under FWP conditions BM acreages were calculated by applying the project-induced reduction in rate of loss to 1990 BM acreage, and subtracting the acreage which would revert to F/IM. A 2-step process was used to compute the FWP acreage.

Step 1. Using FWOP BM acreages previously computed and the BM acreage which converted to F/IM (computed in Step 2 for F/IM), subtract the latter from the former for 1991 and 2000.

1991 128,978 (FWOP) - 4,287 (from F/IM) = 124,691 acres in 1991

2000 123,288 (FWOP) - 4,098 (from F/IM) = 119,190 acres in 2000

Subtract resulting 2000 acreage from 1991 acreage.

124,691 - 119,190 = 5,501 acres to which the project-induced loss rate would be applied.

Step 2. Apply the 10 percent project-induced loss rate by multiplying the final acreage difference computed in Step 1 by the reciprocal of 0.10 (0.90).

5,501 x 0.90 = 4,951 acres for FWP condition

Subtract the reduced loss from the 1991 acreage adjusted to exclude the acreage which would be converted to F/IM.

124,691 - 4,951 = 119,740 acreas of BM remaining in 2000 under FWP conditions.

BM acreages for 10 year increments were computed in the same manner and the results are shown on table D-4-2.

Step 2. The BM acreage which would convert to F/IM consisted of 4,576 acres in 1978. The reciprocal of the 0.50% annual brackish marsh loss rate (0.995) was applied to this acreage in the manner described for FM for the Mississippi portion of the study area. The acreage for 1991 was computed to be 4,287. These calculations were continued for the remaining years of the project life. Using the acreages derived in these calculations, subtract 2000 acreage from that of 1991:

4,287 - 4,098 = 189 acres lost under FWOP conditions.

Multiply the difference by the reciprocal of 0.10 (0.90) to account for the project-induced 10% loss reduction.

189 x 0.90 = 170 acres lost under FWP conditions

Subtract the reduced loss from 1991 acreage to determine the projected acreage for 2000.

4,287 - 170 = 4,117 acres in 2000 under FWP conditions

The totals from both steps were then added resulting in a sum 55,513 acres present in 2000 under FWP conditions. F/IM acreages for years 2010, 2020, 2030, and 2040 were computed in the same manner and the results are shown on table D-4-2.

Brackish Marsh

D.4.22. As for F/IM, the reduced loss rate was applied to the marsh acreage from 1991 through the project life. Acreages were computed for 10 year increments through 2040. Acreage for 1990 was the same for FWOP and FWP conditions.

proximity to the marine environment of Chandeleur and Mississippi Sounds. However, some SM adjacent to the BM would likely experience a reduced loss rate.

Fresh/Intermediate Marsh

D.4.21. The proposed diversion was assumed to begin in 1990; beneficial effects to the marsh would begin to occur by 1991. Thus, the project-induced reduced loss rate was applied to the marsh acreage in 1991 and thereafter. The project life was divided into 10-year increments or target years. After 1990, F/IM acreage would consist of the 1990 F/IM area plus the BM acreage adjacent to the Bonnet Carre' Spillway which would convert to F/IM. The post 1990 F/IM acreage was computed in a 2-step process; first the acreage derived from the area that was F/IM in 1990 was computed. Then the acreage which would be BM under FWOP conditions was calculated. The results were then combined to obtain FWP F/IM acreages.

Step 1. Using FWOP F/IM acreages previously computed, subtract year 2000 acreage (51,111) from year 1991 acreage (53,956):

53,956 - 51,111 = 2,845 acres lost under FWOP conditions

Multiply the difference by the reciprocal of 0.10 (0.90) to account for the project-induced 10% reduction in loss.

2,845 x 0.90 = 2,560 acres lost under FWP conditions

Subtract the acres lost under FWP conditions from 1991 acreage to determine acreages remaining in 2000

53,956 - 2,560 = 51,396 acres remaining in the year 2000.

D.4.19. The diversion of nutrient-laden Mississippi River flows into the study area would also benefit marshes in the Louisiana portion in a more subtle way. Although marsh type boundaries are not expected to change other than as discussed above, beneficial changes are expected to occur within the marshes, as the proposed diversion would result in a slightly lower annual salinity regime and increased nutrient and sediment transport to the area. The proposed diversion is expected to result in increased plant growth and species diversity, especially in the F/IM and BM. Artificial enrichment of emergent marsh vegetation with nutrient-rich waste water from a menhaden processing plant in coastal Louisiana increased the growth of bulltongue, softstem bulrush, and wiregrass by 30 to 51 percent (Payonk, 1975). The far greater nutrient content of Mississippi River water compared to that of adjacent estuaries unaffected by river discharge has been well documented (Ho and Barrett, 1975). Also documented is the fact that lowered salinities during the growing season will result in increased seed germination and plant growth of F/IM and BM species important to wildlife (Palimisano, 1971). The increased plant growth and sedimentation would reduce the rate of marsh deterioration by enabling the marsh to better withstand the effects of subsidence (Delaune et al., 1978). The effects of riverine overbank flow on adjacent, deteriorating marshes has been shown to reduce and in some cases reverse the deterioration process (Baumann and Adams, 1982).

D.4.20. Project benefits in terms of reduced marsh deterioration rates cannot be precisely quantified. This a reasonable assumption was made that F/IM and BM loss rates would be reduced by 10% and SM loss rates would not be affected. This assumption was based on a comparison of FWOP and FWP conditions for this study and for the Louisiana Coastal Area study where salinity regimes would be moderated to a greater extent with larger marsh loss rate reductions. No SM loss rate reduction was projected because of its distance from the discharge area and its close

and oil and gas development are planned for this area and natural processes such as subsidence will continue. It is expected that the effects of saltwater intrusion will continue, but at a lesser rate than before. The average annual loss rate was computed in the manner previously described for other wetland types and was determined to be 1.29%. WS acreages by target year are listed in table D-4-2.

D.4.17 BLH acreage decreased from 54,304 acres in 1955/56 to 48,338 acres in 1978. This 11% decrease resulted primarily from residential, industrial, agricultural, and transportational development. It was assumed that this rate of development would continue in the future. The average annual loss was computed in the manner previously described for other wetland types and was determined to be 0.50%. BLH acreages by target year for FWOP conditions are listed in table D-4-2.

FUTURE WITH-PROJECT CONDITIONS

D.4.18. The most pronounced effect of the proposed freshwater diversion on study area marshes would occur nearest the diversion site. Marshes located further away from the diversion site would be affected less. It was projected that the BM adjacent to the Bonnet Carre' Spillway would be converted to F/IM as a result of the reduced annual salinity extremes projected to occur under FWP conditions. This maximum salinity, 2 ppt, falls within the range for F/IM (0-5 ppt). It was assumed that the trend of WS converting to F/IM would cease along the western shore of Lake Pontchartrain as the annual salinity extremes responsible for this trend (Wicker et al., 1981) would be reduced to less than 2 ppt. These projections are based on previously observed marsh responses to freshwater discharges in coastal Louisiana (Chabreck and Linscombe, 1982; van Beek et al., 1982).

Acres of suitable bottom	6,000	ac
Convert to square meters	x 4,047	m^2/ac
Square meters of suitable bottom	24,282,000	m^2
Multiply by 20 oysters/m^2	x 20	
Total number of oysters produced	485,640,000	oysters
Convert to gallons of oysters[1/]	÷ 200	oysters/gal
Gallons of oyster produced	2,428,200	gal.
Convert to pounds of oyster meat[2/]	x 8.75	lbs./gal
Pounds of meat produced biannually	21,246,750	lbs
Convert to annual production	÷ 2	yrs.
Average annual production	10,623,375	lbs/yr.

The above calculations indicate that 10,623,375 pounds of oyster meat could be produced annually on the 6,000 acres of suitable, historically productive bottoms within the optimal zone on the public grounds. However, the analysis required one more step, and that was to determine what portion of these oysters would actually be harvested by fishermen. This, of course, is the figure which would be meaningful in the economic analysis of project benefits. Hard data on this aspect is not readily available. The percentage of oysters actually harvested from a given area varies considerably. In an area which consistently produces oysters on a long-term basis, the fishermen learn the area very well and are able to harvest a large percentage of the oysters. However, areas which only produce oysters occasionally, due to unusual environmental conditions, are not as familiar to the fishermen and the percentage of oysters harvested is not as high. In this analysis, it was assumed that 50 percent of the oysters produced could be harvested. This is probably a conservative estimate, because under

1/ A gallon of shucked oyster meat contains an average of 200 individual oysters.

2/ National Marine Fisheries Service uses an average of 8.75 pounds of meat per gallon of shucked oysters.

with-project conditions, oyster production in a given area would be more consistent and the fishermen would become very familiar with the areas of sustained production. Using a harvest value of 50 percent of the oysters produced in the optimal zone of the public oyster bottoms, pounds of oyster meat harvested per year were calculated as follows:

10,623,375 lbs produced/yr x .50 harvested =
5,311,688 lbs harvested/yr in optimal zone on public bottoms

D.5.11. Calculations of oyster benefits for the secondary zone were performed in basically the same manner as outlined above for the optimal zone. Using Captain Pausina's map, it was determined that approximately 2,068 acres of historically productive, public reef areas lie within the zones of secondary production. Once again, it was assumed that 75 percent of the area (1,551 acres) would provide suitable substrate for oyster production. Using the area of 1,551 acres and a productivity factor of 10 oysters/m^2, with-project oyster production within the secondary zones on Louisiana's public bottoms was derived as follows:

Acres of suitable bottom	1,551 ac
Convert to square meters	x 4,047 m^2/ac
Square meters of suitable bottom	6,276,897 m^2
Multiply by 10 oysters/m^2	x 10 oysters/m^2
Total number of oysters produced	62,768,970 oysters
Convert to gallons of oysters	÷ 200 oysters/gal
Gallons of oysters produced	313,845 gal
Convert to pounds of oyster meat	x 8.75 lbs/gal
Pounds of meat produced biannually	2,746,143 lbs
Convert to annual production	÷ 2 yrs
Average annual production	1,373,071 lbs/yr

As previously described for the zone of optimal production, it was necessary to calculate the percentage of oysters produced in the secondary zones which would actually be harvested by the fishermen. Once again, it was assumed that 50 percent of the oysters would be harvested. Therefore, pounds of oyster meat harvested per year were calculated as follows:

1,373,071 lbs produced/yr x .50 harvested =
686,536 lbs harvested/yr in secondary zones on public bottoms

D.5.12. Based on the preceding calculations, with project harvest of oysters from both the optimal and secondary production zones of Louisiana's public oyster bottoms are:

5,311,688	lbs harvested/yr in optimal zone
+ 686,536	lbs harvested/yr in secondary zones
5,998,224	lbs harvested/yr from public bottoms

D.5.13. Oyster production on leased water bottoms was then projected for both the optimal and secondary zones. Using LDWF oyster lease maps and acreage data, it was determined that 25,156 acres of water bottoms are leased for oyster production in the optimal zone. Only a portion of this acreage consists of suitable bottoms. The actual area of suitable substrate varies from lease to lease and the percentage is not well documented. For purposes of this analysis, it was assumed that only 15 percent (3,773 acres) of leased acreage in the optimal zone consists of suitable bottom. This percentage was considered to be reasonable by the CE, LDWF, and USFWS personnel performing this analysis. Using the area of 3,773 acres and a productivity factor of 20 oyster/m^2, with-project oyster production within the optimal zone on Louisiana's leased bottoms was derived as follows:

Acres of suitable bottom	3,773	ac
Convert to square meters	x 4,047	m^2/ac
Square meters of suitable bottom	15,269,331	m^2
Multiply by 20 oysters/m^2	x 20	oysters/m^2
Total number of oysters produced	305,386,620	oysters
Convert to gallons of oysters	÷ 200	oysters/gal
Gallons of oysters produced	1,526,933	gal
Convert to pounds of oyster meat	x 8.75	lbs/gal
Pounds of meat produced biannually	13,360,665	lbs
Convert to annual production	÷ 2	yrs
Average annual production	6,680,332	lbs/yr

The above calculations indicate that 6,680,332 pounds of oyster meat could be produced annually on the 3,773 acres of productive bottoms within the optimal zone on the leased grounds. As with the analysis for the public reefs, the percentage of these oysters which would actually be harvested by the fishermen must be taken into account. It was assumed that 75 percent of the oysters produced would be harvested. This percentage is greater than that estimated for the public grounds because the fishermen know exactly where their oysters are on their leases. In fact, this is probably a conservative estimate. Using a harvest value of 75 percent of the oysters produced in the optimal zone of leased oyster grounds, pounds of meat harvested per year are calculated as follows:

6,680,332 lbs produced/yr x .75 harvested =
5,010,249 lbs harvested/yr in optimal zone on leased bottoms

D.5.14. Calculations of oyster benefits for leased bottoms in the secondary zones were performed basically in the same manner as outlined above for the optimal zone. Using LDWF lease information, it was determined that approximately 7,595 acres of water bottoms are leased for oyster production in the secondary zones. It was assumed that 15 percent (1,139 acres) of leased acreage consists of suitable bottom. Using the area of 1,139 acres and a productivity factor of 10

oysters/m^2, with-project oyster production within the secondary zones on Louisiana's leased grounds was derived as follows:

Acres of suitable bottom	1,139	ac
Convert to square meters	x 4,047	m^2/ac
Square meters of suitable bottom	4,609,533	m^2
Multiply by 10 oysters/m^2	x 10	oysters/m^2
Total number of oysters produced	46,095,330	oysters
Convert to gallons of oysters	÷ 200	oysters/gal
Gallons of oysters produced	230,477	gal
Convert to pounds of oyster meat	x 8.75	lbs/gal
Pounds of meat produced biannually	2,016,671	lbs
Convert to annual production	÷ 2	yrs
Average annual production	1,008,335	lbs/yr

As previously described for the zone of optimal production, it was necessary to calculate the percentage of oysters produced in the secondary zones which would actually be harvested by the fishermen. Once again, it was assumed that 75 percent of the oysters would be harvested. Therefore, pounds of oyster meat harvested per year were calculated as follows:

1,008,335 lbs produced/yr x .75 harvested =
756,251 lbs harvested/yr in secondary zones on leased bottoms

D.5.15. Based on the preceding calculations, with-project harvest of oysters from both optimal and secondary zones of Louisiana's leased oyster bottoms are:

5,010,249 lbs harvested/yr in optimal zone
+ 756,251 lbs harvested/yr in secondary zone
5,766,500 lbs harvested/yr from leased bottoms

D.5.16. The total with-project annual harvest of oysters in the Louisiana portion of the study area is shown below.

5,998,224 lbs harvested/yr from public bottoms
+5,766,500 lbs harvested/yr from leased bottoms
11,764,724 lbs harvested/yr from Louisiana

D.5.17. The following discussion describes the methodology and presents the results of the with-project oyster analysis in the Mississippi portion of the study area. The analysis is basically similar to that used in Louisiana in that the benefits are keyed to the findings of the LDWF study. The linking of optimal salinities and suitable, historically productive oyster bottoms is valid in both states. Today, over 90 percent of the oysters harvested in Mississipi come from the oyster reefs in the western portion of Mississippi Sound. This is the area which would be affected by the MLEA freshwater diversion structure. Historically productive areas to the east, in the vicinity of Biloxi and Pascagoula, are currently permanently closed to oyster harvest due to pollution, and have been for a number of years.

D.5.18. The optimal and secondary salinity zones previously defined for the Louisiana portion of the study area extend into Mississippi Sound and intercept the coastline near the mouth of St. Louis Bay on the west and the Gulfport ship channel on the east. This zone basically encompasses the entire area in which Mississippi oyster production occurs (Plate 1). The primary reefs include the Pass Christian tonging reef, Pass Christian dredging reef, Pass Marianne, Telegraph Key, Merrill Coquille, and Square Handkerchief. Gunter (1975) stated that oysters are harvested from as many as 7,500 acres in good years. William J. Demoran (personal communication, April 1983) agrees that 7,500 acres is a reasonable figure and is a valid estimate of productive oyster bottoms in the area. Demoran (1966) stated that the Pass

Christian reefs constitute one of the largest nearly continuous oyster reefs in the world. He is Chief of the Fishery Management Section of the Gulf Coast Research Laboratory and has worked in the area of oyster biology and with the oyster industry in Mississippi for over 30 years. Demoran supervised the oyster management program for the Mississippi Marine Conservation Commission from 1960 to 1974. According to Gunter (1975), Demoran was primarily responsible for quadrupling Mississippi's oyster production from 1960-1969. He is considered the leading authority on oyster reef conditions in the state.

D.5.19. Although the general areal extent and configuration of Mississippi reefs have been mapped, the exact boundaries of each reef area are not well documented. Therefore, it was not possible to determine the acreages within each of the optimal and secondary zones of production. It was suggested and assumed that an average productivity of 15 oysters/m^2 be used in the benefit calculations since the area could not be readily divided into the zone which would produce an average of 20 oysters/m^2 versus the zone which would produce an average of 10 oysters/m^2, as was the case in the Louisiana analysis. In addition, to maintain a conservative posture and for the same reasons as previously described in the Louisiana analysis, it was assumed that 75 percent of the 7,500 acres (5,625 acres) described in paragraph D.5.18 would provide suitable substrate for oyster production. Using the area of 5,625 acres and a productivity factor of 15 oysters/m^2, with-project oyster production in Mississippi was derived as follows:

Acres of suitable bottom	5,625	ac
Convert to square meters	x4,047	m^2/ac
Square meters of suitable bottom	22,764,375	m^2
Multiply by 15 oysters/m^2	x 15	oysters/m^2
Total number of oysters produced	341,465,625	oysters
Convert to gallons of oysters	÷ 200	oysters/gal
Gallons of oysters produced	1,707,328	gal
Convert to pounds of oyster meat	x 8.75	lbs/gal
Pounds of meat produced biannually	14,939,121	lbs
Convert to annual production	÷ 2	yrs
Average annual production	7,469,561	lbs/yr

The above calculations indicate that 7,469,561 pounds of oysters could be produced on the 5,625 acres of productive and historically productive bottoms in Mississippi. However, as was done in the Louisiana analysis, it was necessary to determine the quantity of those oysters which would be harvested by the fishermen. Once again, it was assumed that 50 percent of the oysters would be harvested. Therefore, pounds of meat harvested per year were calculated as follows:

7,469,561 lbs produced/yr x .50 harvested =
3,734,781 lbs harvested/yr in Mississippi

D.5.20. The total with-project annual harvest of oysters from both the Louisiana and Mississippi portions of the study area is shown below.

11,764,724	lbs harvested/yr from Louisiana
3,734,781	lbs harvested/yr from Mississippi
15,499,505	lbs harvested/yr from study area

D.5.21. The with-project oyster harvest which has been derived and quantified in this section has been compared with production under the

without project condition and analyzed with regard to the various economic factors related to the oyster industry. This analysis is presented in Appendix E, Economics.

5.5.22. The methodology employed in this analysis is a state-of-the-art approach. It is acknowledged that finite information and documentation is not available for all of the factors involved. Therefore, every attempt has been made to incorporate the expert opinion and judgement of individuals who are recognized authorities in this field. In addition, efforts were made to insure that all assumptions are reasonable and conservative in order to take into account such unforeseeable events as years where, due to a variety of factors, abnormally low salinities occur throughout the study area. Man has no control over climatic phenomena of this magnitude, nor can he accurately predict the frequency of occurence of such events.

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FINAL FISH AND WILDLIFE
COORDINATION ACT REPORT

EXECUTIVE SUMMARY

The attached document is the report of the Fish and Wildlife Service (FWS) on the tentatively selected plan (TSP) for introduction of Mississippi River water into the Lake Pontchartrain Basin and Mississippi Sound of southeastern Louisiana and coastal Mississippi, respectively. The TSP was developed via the Mississippi and Louisiana Estuarine Areas Study, authorized by a resolution of the Committee on Public Works and Transportation of the United States House of Representatives, adopted on September 26, 1976. The attached report was prepared in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401., as amended; 16 U.S.C. 661 et seq.).

The TSP provides for diversion of Mississippi River water via a control structure to be located adjacent to Bonnet Carre Spillway in St. Charles Parish, Louisiana. The structure would divert up to 30,000 cubic feet per second of river water into Lake Pontchartrain and Mississippi Sound. The diversion structure would consist of gated box culverts located in the Mississippi River levee, which could control the amount of freshwater introduced so that optimal salinity conditions could be maintained on an average of one year out of two.

The proposed freshwater diversion would reduce the rapid loss of wooded swamp and marsh acreage being experienced in the Louisiana portion of the study area. Studies have documented dramatic declines in marsh acreages in this area between the mid-1950's and 1978. Total marsh acreage in the Louisiana portion of the study area declined from 340,000 acres in the mid-1950's to 252,000 acres by 1978. Fresh marsh declined from 66,000 acres in the mid-1950's to 33,000 acres by 1978. The combined wooded swamp and bottomland hardwood acreage in the Louisiana portion of the study area decreased 68,000 acres during this period. These wetland losses are expected to continue over the next 50 years at an average annual rate of 2,500 acres, unless remedial action is taken. The rate of decline in wetland acreage in the Mississippi portion of the study area has been relatively low; the wetland losses in Mississippi over the next 50 years are expected to average 230 acres annually. The proposed freshwater diversion would not affect this rate of loss.

The primary area of project influence includes the Lake Pontchartrain Basin and Mississippi Sound. Important fish and wildlife habitats in these basins include bottomland hardwood forests, wooded swamps, fresh to saline marshes, and fresh and estuarine open waters; these habitats support an abundance of fish and wildlife. Fishery resources are comprised of freshwater and estuarine-dependent types, with both sport and commercial activities being of great importance. Important wildlife species include migratory and resident waterfowl and other marsh birds (rails, gallinules, and snipe); colonially nesting wading birds, shorebirds and seabirds; numerous other non-game birds; white-tailed deer; small game mammals; fur animals; and numerous reptiles and amphibians including the American alligator. Endangered or threatened species are not expected to be adversely affected by the TSP. Wildlife management areas and refuges operated by the

Louisiana Department of Wildlife and Fisheries (LDWF) in the study area include Biloxi Wildlife Management Area (WMA), Manchac WMA, Pearl River WMA, Joyce WMA, and St. Tammany Wildlife Refuge. Breton National Wildlife Refuge (NWR), Mississippi Sandhill Crane NWR, and Bogue Chitto NWR are located in or adjacent to the study area and are managed by the FWS.

A detailed analysis of project impacts on fish and wildlife resources was conducted. The FWS's Habitat Evaluation Procedures (HEP) were employed to assess project impacts on wildlife habitat quality and quantity (Appendix A). An analysis of the TSP's anticipated impacts on economically important fish and wildlife species and associated human uses was also performed (Appendix B). These analyses were based primarily on a comparison of future without-project and future with-project acreages over the anticipated 50-year project life (1990 to 2040).

The proposed diversion structure and associated channel will result in modification ot existing habitats at the recommended site. About 618 acres of wooded swamp, 63 acres of borrow pit and open water, 1,078 acres of disturbed land, and 52 acres of residential areas and levee will be impacted by the construction and maintenance of the recommended diversion feature. The greatest impact of the TSP on fish and wildlife habitat, however, will be in the reduction of wooded swamp and marsh loss in the Louisiana portion of the study area and the maintenance of a more favorable salinity regime in both the Lake Pontchartrain Basin and Mississippi Sound. The reduction in wetlands loss is attributed to reduced saltwater intrusion and increased input of nutrients and fine-grained sediments. In the Louisiana portion of the study area, combined wooded swamp and marsh acreage is expected to decrease from 367,200 acres in 1990 to 241,600 acres in 2040 under without-project conditions. With the proposed diversion, a total of 252,100 acres will remain in the year 2040. On an average annual basis, there will be 5,700 more acres of wooded swamp and marsh in the study area under with-project conditions, compared to without-project conditions.

Studies conducted by the New Orleans District Corps of Engineers (NODCE) Recreation Planning Section considered freshwater and saltwater sportfishing as a single category. Those studies revealed that under without-project conditions access to sportfishing areas will continue to be inadequate, causing sportfishing effort to remain constant throughout the analysis period (1990 to 2040). However, sportfishing effort will increase under with-project conditions as construction of additional access facilities are included in the TSP. As a result, under with-project conditions the average annual value of sportfishing is projected to increase by $411,000. Project impacts on freshwater commercial fisheries, which comprise less than one percent of the total commercial fishery harvest in the study area, were not quantified. However, the proposed diversion will increase the habitat of commercially important freshwater fishes.

Because of the reduction in wetlands loss and the creation of more favorable salinity conditions, the proposed diversion will greatly benefit estuarine-dependent commercial fisheries. With the project, there will be a net increase (i.e., reduction in loss) in the average annual commercial harvest of shrimp, crabs, and finfishes amounting to 716,000 pounds, having a net value of $59,000. Commercial oyster harvest will increase, on an average annual basis, by 7.5 million pounds, having an average net value of $6.5 million.

The project-related reduction in wetlands loss will also benefit wildlife populations and associated sport and commercial uses. Net increases in average annual populations of selected wildlife species include 70 white-tailed deer; 3,030 swamp rabbits; and 40 nesting pairs of both mottled ducks and wood ducks. With-project increases in the average annual sport hunting use include 580 man-days of deer hunting; 3,410 man-days of small game hunting; 1,320 man-days of waterfowl hunting; and 410 man-days of hunting for other migratory birds (rails and snipe). The with-project increase in the average annual net returns for fur animal harvest are valued at $17,000, while increases for alligator harvest are valued at $4,000. The total annual benefits of the proposed diversion are valued at more than $7.1 million.

The HEP analysis revealed that construction and maintenance activities at the proposed diversion site will have relatively minor impacts on wildlife habitat. The greatest impacts of the TSP are associated with reduction in wetlands loss and creation of more favorable salinity conditions in the areas affected by diverted fresh water. With-project gains in Average Annual Habitat Units (AAHU's) will be realized for all species evaluated. These gains include 4,300 AAHU's for nutria; 2,300 AAHU's for muskrats; 4,000 AAHU's for puddle ducks; and 3,400 AAHU's for alligators.

Under the TSP, operation and maintenance of the proposed structures would be a non-Federal responsibility. No specific division of this responsibility has yet been determined by the States of Louisiana and Mississippi or the local governing bodies which would be directly affected by the project. The LDWF and the Mississippi Bureau of Marine Resources (MBMR) would be the most logical candidates for that task. Operational guidelines would be developed during the design stages by Federal, State, and local agencies having expertise in fish and wildlife management, flood control, and public health. Monitoring of the project area would include water quality, vegetation, wildlife populations, and contaminant levels. Coordination of existing monitoring programs would achieve many monitoring goals.

The FWS recommends that the following measures be implemented in the interest of fish and wildlife conservation:

1. The tentatively selected plan be recommended for authorization in the final feasibility report, and

2. The final feasibility report request authority for funding of post-authorization studies to include participation of the

INTRODUCTION

The Mississippi and Louisiana Estuarine Areas Study is being conducted under the leadership of the New Orleans District, Corps of Engineers (NODCE). The study was authorized by a resolution of the Committee on Public Works and Transportation of the United States House of Representatives, adopted on September 26, 1976. The resolution authorized investigations to determine the advisability of providing supplemental fresh water to Lakes Maurepas, Pontchartrain, Borgne, and the Mississippi Sound area in the interest of improving the wildlife and fisheries of the area.

Introduction of fresh water from the Mississippi River into Lake Pontchartrain through the Bonnet Carre Spillway has been identified as the best means of achieving the study goal. This report provides an analysis of the effects, on fish and wildlife, of the tentatively selected freshwater diversion site and provides recommendations regarding operation of these structures; this report fulfills the Fish and Wildlife Service's responsibilities for this feasibility study under provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

PROJECT DESCRIPTION

The tentatively selected plan includes diversion of Mississippi River water via a structure immediately west of the Bonnet Carre Spillway (Figure 1). The structure would be capable of diverting a maximum flow of 30,000 cubic feet per second through a multi-gated box culvert and would be located in the Mississippi River levee in St. Charles Parish, Louisiana. The water would enter the diversion structure via a 950-foot-long inflow channel having a bottom width of 400 feet. The diverted water would then flow through a 6.4-mile-long outlet channel (bottom width 400 feet) in the Bonnet Carre Spillway to Lake Pontchartrain. From Lake Pontchartrain, the diverted water would flow through Chandeleur Sound and the western half of Mississippi Sound. The diversion structure would be comprised of four box culverts, each measuring 20 feet by 20 feet and having an invert (sill) elevation of -21.0 feet National Geodetic Vertical Datum (NGVD). The upstream (western) guide levee of the Bonnet Carre Spillway would be relocated to the west to inclose the structure and outlet channel within the spillway. Excavated material in the spillway would be placed adjacent to the diversion channel and would be eventually removed by commercial sand haulers for use as fill for construction activities in surrounding urban areas. Some of the excavated material suitable for levee construction may be used to construct the relocated upper guide levee. A sediment trap 1,450 feet long and 780 feet wide would be excavated in the diversion channel 3,500 feet downstream of the diversion structure. The bottom elevation of the sediment trap would be -36.0 feet NGVD.

Recreational facilities would be developed at six sites in the study area. Four sites would be located along Lake Pontchartrain; the

Page

LIST OF TABLES

APPENDIXES

LIST OF TABLES

LIST OF TABLES
(cont.'d)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

MISSISSIPPI AND LOUISIANA ESTUARINE AREAS STUDY

FISH AND WILDLIFE COORDINATION ACT REPORT

SUBMITTED TO

NEW ORLEANS DISTRICT

U.S. ARMY CORPS OF ENGINEERS

NEW ORLEANS, LOUISIANA

PREPARED BY

GERALD W. BODIN

FISH AND WILDLIFE BIOLOGIST

UNDER THE SUPERVISION OF

DAVID W. FRUGE, FIELD SUPERVISOR

U.S. FISH AND WILDLIFE SERVICE

DIVISION OF ECOLOGICAL SERVICES

LAFAYETTE, LOUISIANA

APRIL 1984

WILLIAM WINTER
Governor

MISSISSIPPI DEPARTMENT OF WILDLIFE CONSERVATION

Bureau of Marine Resources
P. O. Drawer 959
Long Beach, MS 39560
(601) 864-4602
Enforcement
Division - 374-3205

September 23, 1983

Mr. David M. Soileau
Acting Field Supervisor
U.S. Fish and Wildlife Service
P.O. Box 4305
Lafayette, LA 70502

Dear Mr. Soileau:

Thank you for the opportunity to review your draft report on Mississippi and Louisiana Estuarine Areas Study. After careful biological staff review, it was decided that your report is on target. The Mississippi Bureau of Marine Resources emphatically supports the freshwater inflow project and shall be available to participate in any phase of the project which we possibly can.

Thank you again for the opportunity to review your draft report. Please contact this agency if we may be of any future assistance.

Sincerely,

Richard L. Leard, Ph.D.
Bureau Director

RLL:JRH:mac

State of Louisiana

DEPARTMENT OF WILDLIFE AND FISHERIES
POST OFFICE BOX 15570
BATON ROUGE, LA 70895

J. Burton Angelle, Sr.

Edwin W. Edwards

April 13, 1984

Mr. David Fruge'
Field Supervisor
U. S. Fish and Wildlife Service
P. O. Box 4305
Lafayette, Louisiana 70502

Re: Fish and Wildlife Coordination Act Report: Mississippi and Louisiana Estaurine Areas, Freshwater Diversion to Lake Pontchartrain Basin and Mississippi Sound

Dear Mr. Fruge':

We have reviewed the above referenced Coordination Act report produced by your office. As you are aware, our technical personnel have worked in close cooperation with representatives of your agency, the Corps of Engineers (N.O.D.), and other agencies in the assessment of impacts on fish and wildlife habitat and resources that would result from the tentatively selected freshwater diversion proposal. To a considerable extent, this department's involvement has been concerned with basic research and documentation of salinity conditions most conducive to high oyster yields, and the development of estimates of project-related increases in oyster production that would result from restoration of optimal salinity regimes over historically productive oyster bottoms.

We agree with the Coordination Act report's conclusions, and concur that the tentatively selected diversion plan be recommended for authorization with requests for funding of cooperative studies, involving this department and other federal and state fish and wildlife agencies, for the design and development of the proposed structures, their operation and maintenance, and the necessary environmental monitoring programs.

Sincerely yours,

J. Burton Angelle

J. Burton Angelle
Secretary

JBA/CJK/fsb

LITERATURE CITED

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Zein-Eldin, Z. P., and G. W. Griffith. 1969. An appraisal of the effects of salinity and temperature on growth and survival of postlarval penaeids. FAO Fish. Rpt. 3(57): 1015-1026.

The final report should also address the considerable evidence that the reduced salinities, such as would result from project implementation, would benefit crustaceans and fishes in manners other than just increasing marsh acreage. For instance, a Fish and Wildlife Coordination Act report for a project to increase freshwater inflows into Matagorda Bay, Texas, noted the following with regard to low salinity benefiting early life states of white and brown shrimp and blue crabs:

"White shrimp apparently require low salinity waters during some of their early life stages. According to Gunter et al. (1964) the optimum salinity for post-larval and juvenile white shrimp ranges from 0.5 to 10.0 ^{o}/oo. However, based on their laboratory studies, Zein-Eldin and Griffith (1969) reported that at 30^{o}C twice as much tissue was produced by post-larval white shrimp at salinities of 5 and 15 ^{o}/oo than at salinities of 25 and 35 ^{o}/oo. Approximately 30^{o}C is a common temperature for shallow, marsh nursery areas during the summer."

"Studies performed for the Corps' Waterways Experiment Station (Venkataramiah et al., 1974 and 1977) showed that young brown shrimp fare best in lower salinities. Although the juvenile brown shrimp (70 mm mean length) can survive a wide salinity range, the best growth and survival rates were obtained in salinities of 8.5 to 17.0 ^{o}/oo salinity.

In a blue crab study of Texas, More (1969) noted that juvenile blue crab became progressively less abundant as salinity increased. Rounsefell (1964) reported similar findings in Louisiana. The blue crabs' preference for brackish water and the tendency of small individuals to distribute themselves in waters of low salinity has been reported by Churchill (1919) and Gunter (1950)."

In addition, in a study conducted in some of this project's area, Mississippi Sound, Christmas and Langley (1973) reported greatest catches of small brown shrimp in the salinity interval of 15.0 to 19.9 ^{o}/oo, and an optimum salinity range for white shrimp of 10.0 to 19.9^{o}/00.

In consideration of all the above, we recommend that the final report further address the benefits of lowering the salinity of the project area to marine fishery species in addition to oysters, especially shrimps and crabs.

Thank you for the opportunity to review this draft report.

Sincerely yours

Richard J. Hoogland
Chief, Environmental Assessment
Branch

Enclosure

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Region
9450 Koger Boulevard
St. Petersburg, FL 33702

December 6, 1983 F/SER112/DM:gog
409/766-3699

Mr. David W. Fruge
Field Supervisor
U.S. Fish and Wildlife Service
P. O. Box 4305
103 East Cypress Street
Lafayette, LA 70502

Dear Mr. Fruge:

This replaces our October 13, 1983 response to your and David M. Soileau's requests that we review your draft Fish and Wildlife Coordination Act report on the tentatively selected plan for freshwater introduction developed under the authority of the Mississippi and Louisiana Estuarine Areas Study. You provided us with your revised pages on September 13, 1983. Our revisions and comments are limited to marine and estuarine fishery resources.

The Description of Habitats and the Fishery Resources Sections, with two exceptions, appear to be adequately presented under AREA SETTINGS. The exceptions being that brown and white shrimp and sand and spotted seatrout, respectively, should be presented separately, instead of just grouping them as shrimp and seatrout. These separations would be appropriate since those four important species have different seasons of peak nursery usage and different degrees of apparent dependence of early life stages upon low salinity estuarine habitats. With regard to the sections entitled Habitat Impacts and Fisheries Impacts, under PROJECT IMPACTS the impact assessment for oysters appears adequately presented, while that for shrimp and crabs appears to be insufficiently addressed. On page 43, the first complete paragraph starts by stating that "Because of reductions in habitat loss and the creation of more favorable salinity conditions, the project is expected to substantially benefit estuarine-dependent commerical fishery resources." (emphasis added). However, after noting in Appendix B on the last paragraph of B-5 that "there is growing evidence that the acreage of marsh is the most important factor influencing the production of estuarine-dependent species of sport and commerical importance in the gulf area", the draft only considers changes in the area of marsh in determining expected increases in harvests of fishes and crustaceans.

United States Department of the Interior
FISH AND WILDLIFE SERVICE
75 SPRING STREET, S.W.
ATLANTA, GEORGIA 30303
April 16, 1984

Colonel Robert C. Lee
Commander and District Engineer
U.S. Army Engineer District, New Orleans
Post Office Box 60267
New Orleans, Louisiana 70160

Dear Colonel Lee:

Attached is the Fish and Wildlife Coordination Act Report on the tentatively selected plan described in the draft feasibility report, "Mississippi and Louisiana Estuarine Areas - Freshwater Diversion to Lake Pontchartrain Basin and Mississippi Sound." Our report is transmitted to you under the authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). The report has been coordinated with the Louisiana Department of Wildlife and Fisheries, Mississippi Bureau of Marine Resources, and the National Marine Fisheries Service. Copies of the letters of response from those agencies are attached.

Your cooperation in this matter is appreciated.

Sincerely yours,

Richard T. Huber
Assistant Regional Director—
Habitat Resources

Attachments

FWS, National Marine Fisheries Service, LDWF, MBMR, and the Louisiana Department of Natural Resources (Coastal Management Section) in the design of the proposed structures, the development of operational and maintenance guidelines, and the design of monitoring studies of the affected area.

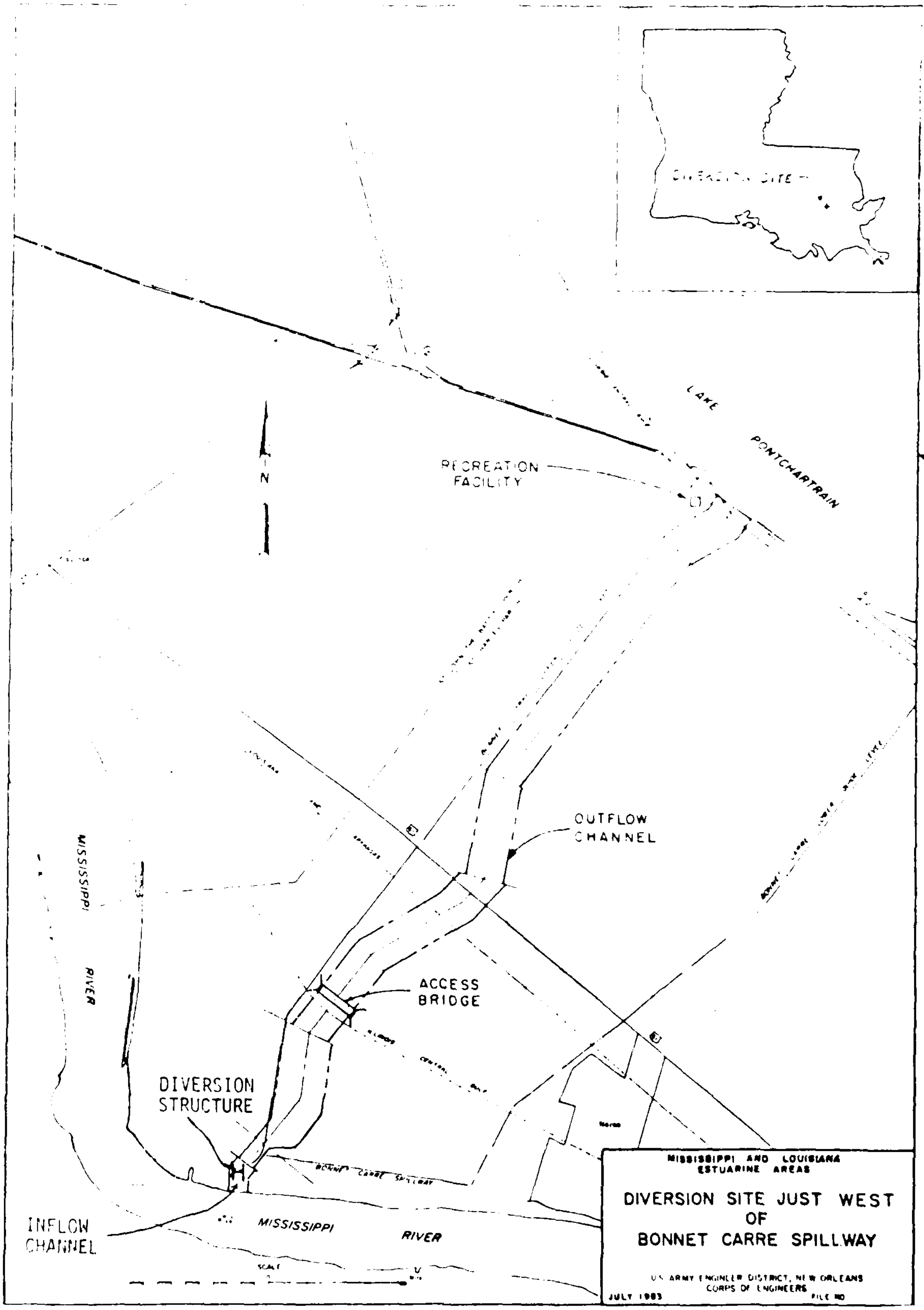
DIVERSION SITE
LAKE PONTCHARTRAIN
N
RECREATION FACILITY
OUTFLOW CHANNEL
MISSISSIPPI RIVER
ACCESS BRIDGE
DIVERSION STRUCTURE
BONNET CARRE SPILLWAY
INFLOW CHANNEL
MISSISSIPPI RIVER
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS
DIVERSION SITE JUST WEST OF BONNET CARRE SPILLWAY
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS CORPS OF ENGINEERS
JULY 1983
FILE NO

FIGURE 1.

locations are as follows: in Bonnet Carre Spillway near the diversion channel, and at Frenier Beach, the Rigoletts, and Point Aux Herbes. The two sites to be provided in Mississippi are located at Cedar Point and Wolf River in the St. Louis Bay area.

The quantity of fresh water diverted during any given period would depend on salinities in the study area. The available volume would be sufficient to produce, one out of two years on the average, optimal salinity conditions for oyster production over large areas of historically productive oyster bottoms in the western portion of Mississippi Sound and the Louisiana marshes east of the Mississippi River-Gulf Outlet. This diversion plan was recommended by an ad hoc interagency group established for this study. The diversion capability would be sufficient to maintain low salinity conditions in the western half of Lake Pontchartrain, on an annual basis. These conditions are necessary to protect the existing palustrine (fresh-water) habitats located there.

AREA SETTING

Introduction

The area to be impacted by the proposed diversion lies within the Mississippi Deltaic Plain Region of southeastern Louisiana and coastal Mississippi, and includes Hydrologic Units I and II, as defined by Wicker (1980). Hydrologic Unit I extends from the Mississippi-Alabama border to the Louisiana-Mississippi border and includes all areas in the coastal zone below 15 feet in elevation. Hydrologic Unit II extends from the Mississippi-Louisiana border to the eastern bank of the Mississippi River from near Donaldsonville, Louisiana, southeastward to Baptiste Collette Bayou near Venice, Louisiana. However, the area in Unit II south of Louisiana Highway 46 and west of the Mississippi River-Gulf Outlet are not included in the study area. The Pontchartrain Basin, Chandeleur Sound, and the Chandeleur Islands are included in the study area. The inland boundary of Unit II is the Louisiana Coastal Zone Management Boundary. Major habitats include bottomland hardwood forest, wooded swamp, fresh to saline marshes, and associated fresh to saline water bodies. The major navigation channels in the area include the Mississippi River, the Mississippi River-Gulf Outlet, the Gulf Intracoastal Waterway, Gulfport Channel, and Pascagoula Channel. The study area boundaries are shown in Figure 2.

Four wildlife management areas and one wildlife refuge operated by the Louisiana Department of Wildlife and Fisheries (LDWF) are located in the study area. These include Biloxi Wildlife Management Area (WMA), Manchac WMA, Pearl River WMA, Joyce WMA and St. Tammany Wildlife Refuge. Details regarding location, size, habitat types, and activities allowed for the first three WMA's listed and the wildlife refuge were provided in a planning aid report prepared by Fish and

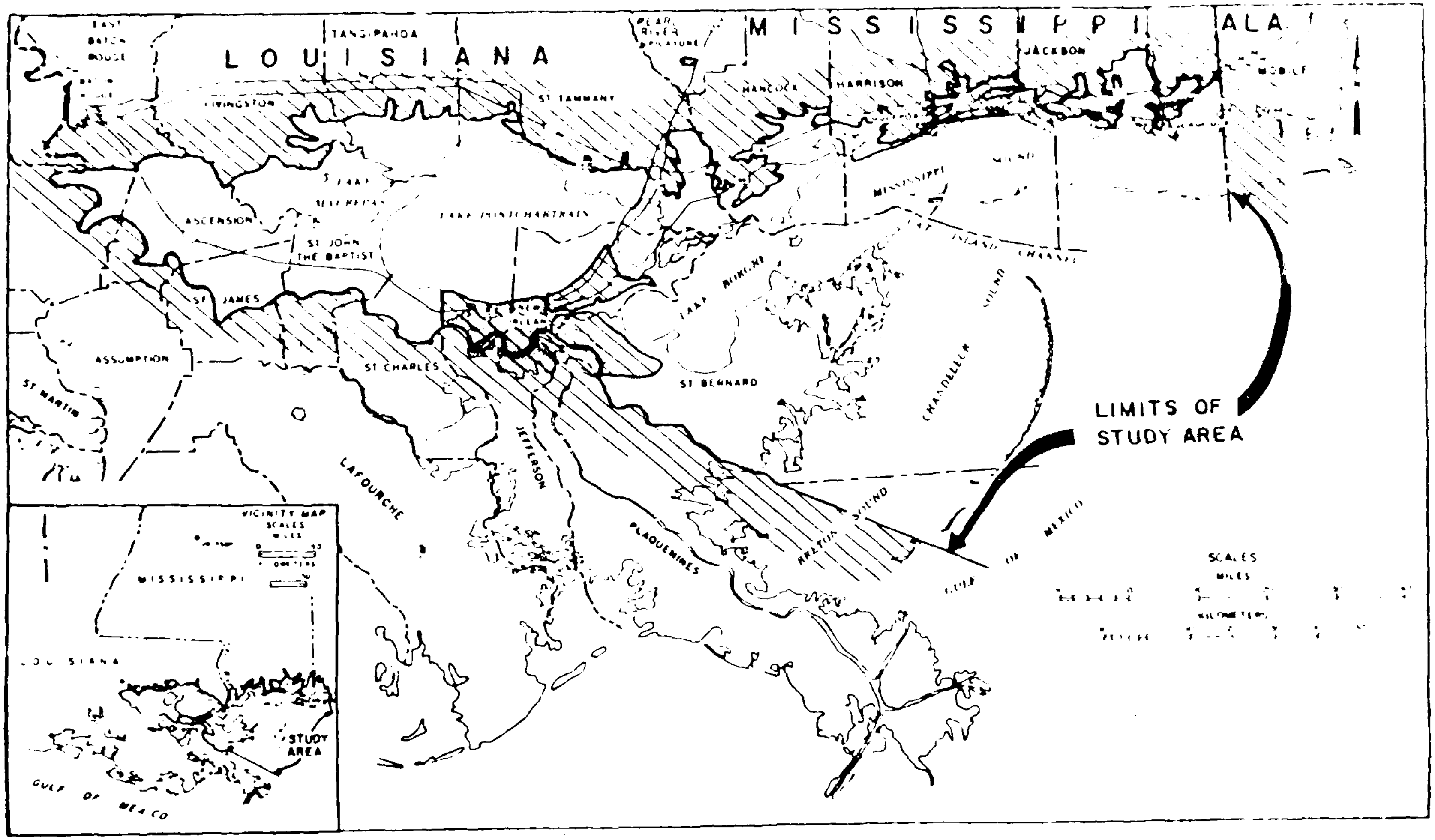

FIGURE 2. PROJECT BOUNDARY, MISSISSIPPI AND LOUISIANA ESTUARINE AREAS

Wildlife Service (FWS) for this study (1980). The 13,659-acre Joyce WMA, established in 1982 and located in Tangipahoa Parish, consists of wooded swamp and offers public hunting and fishing.

Breton National Wildlife Refuge and Mississippi Sandhill Crane National Wildlife Refuge are managed by the FWS and are located in the study area. The previous report by FWS (1980) provided background information on these refuges. Bogue Chitto National Wildlife Refuge, located in St. Tammany Parish, is adjacent to the study area and presently comprises approximately 17,000 acres (purchase of additional lands is authorized). The area is predominantly bottomland hardwood forest and wooded swamp interspersed with numerous streams and sloughs. Public fishing, hunting, and camping are permitted on the refuge.

Description of Habitats

The existing and projected future acreages of vegetated wetland habitats found in the Mississippi and Louisiana portions of the study area are shown in Tables 1 and 2, respectively. These and other habitat types are described below.

It should be noted that the marshes and forested wetlands in the Louisiana portion of the study area are the products of Mississippi River delta development, whereas those habitats in the Mississippi portion of the study area are mainly the products of Pearl River and Pascagoula River delta developments. Levee construction along the Lower Mississippi River, coupled with upstream diversion, bank stabilization and reservoir construction, has greatly reduced freshwater and sediment transport to study-area wetlands in Louisiana. Reduced freshwater inflow and extensive canal dredging has led to saltwater intrusion into this portion of the study area. The net result of these factors has been accelerated subsidence and erosion of marshes and swamps and a conversion to more saline vegetation types.

Recent studies (Wicker 1980) have shown that the total acreage of marsh in the Louisiana portion of the study area declined from 340,000 acres in the mid-1950's to 252,000 acres in 1978, a reduction of nearly 26 percent. An even more dramatic reduction was documented for the fresh marsh category, which declined from 66,000 acres in the mid-1950's to 33,000 acres in 1978, a reduction 50 percent. The combined wooded swamp and bottomland hardwoods (forested wetlands) acreage in the Louisiana portion of the study area decreased 68,000 acres over this same period, amounting to a 25 percent reduction in those habitats. In the Mississippi portion of the study area, the forested wetland acreage remained nearly stable over the 22-year period, whereas total marsh acreage decreased by 8 percent. Fresh marsh acreage decreased by 46 percent over this period, from 6,500 acres in the mid-1950's to 3,500 acres in 1978.

The various marsh, forested wetland, grassbed, and open water habitats were described in the FWS planning aid report (1980) prepared for this

Table 1. Existing (1978) and future without-project wetland habitat acres in the Mississippi portion of the study area (Hydrologic Unit I)

Habitat Type	1978	1990	2000	2010	2020	2030	2040
Bottomland Hardwoods	42,394	41,637	41,017	40,406	39,804	39,210	38,626
Wooded Swamp	33,162	33,162	33,162	33,162	33,162	33,162	33,162
Fresh/Intermediate Marsh	19,885	18,575	17,633	16,802	16,061	15,397	14,795
Brackish Marsh	19,942	19,515	19,167	18,825	18,489	18,159	18,834
Saline Marsh	27,325	26,580	25,975	25,384	24,806	24,241	23,690
Total Marsh	67,152	64,670	62,775	61,011	59,356	57,797	56,319

Table 2. Existing (1978) and future without-project wetland habitat acres in the Louisiana portion of the study area (Hydrologic Unit II)

Habitat Type	1978	1990	2000	2010	2020	2030	2040
Bottomland Hardwoods	48,338	45,516	43,291	41,174	39,161	37,247	35,426
Wooded Swamp	155,507	133,071	118,488	105,681	94,433	84,555	75,880
Fresh/Intermediate Marsh	58,346	54,282	55,513	52,646	49,944	47,400	45,001
Brackish Marsh	137,662	129,626	119,740	114,496	109,508	104,763	100,251
Saline Marsh	56,386	50,223	45,604	41,411	37,603	34,145	31,005
Total Marsh	252,394	234,131	220,857	208,553	197,055	186,308	176,257

study. The classification of these wetland habitat types has been standardized since that time by Cowardin et al. (1979) and is presented below:

Classification used in this report	Classification by Cowardin et al. (1979)
bottomland hardwoods	palustrine forested wetlands
wooded swamp	palustrine forested wetlands
fresh marsh	palustrine emergent wetlands
intermediate marsh	estuarine emergent wetlands
brackish marsh	estuarine emergent wetlands
saline marsh	estuarine emergent wetlands
seagrass bed	estuarine aquatic bed
freshwater grass bed	palustrine aquatic bed
freshwater ponds	palustrine open water
freshwater lakes	lacustrine open water
estuarine open water	estuarine subtidal open water

Fishery Resources

Freshwater

Freshwater finfishing occurs in the fresh to slightly brackish reaches of coastal rivers and in freshwater lakes and ponds of the study area. Species commonly taken include largemouth bass, spotted bass, yellow bass, black crappie, white crappie, warmouth, bluegill, redear sunfish, spotted sunfish, channel catfish, blue catfish, and fiathead catfish. The primary freshwater commercial species harvested in the study area include blue catfish, channel catfish, flathead catfish, yellow bullhead, bowfin, carp, gars, and buffalo fishes. Commercial harvest data (1963-1976) for freshwater species in the Louisiana portion of the study area are available only for catfish and bullheads (Table 3). As noted in Table 3, reported landings peaked in 1963, and have not exceeded 100,000 pounds since 1969. The bulk of the catfish harvest is derived from Lakes Maurepas and Pontchartrain.

Estuarine/Marine

Saltwater fishing in the study area is extensive. Commonly pursued finfishes include spotted seatrout, sand seatrout, red drum, black drum, Atlantic croaker, southern kingfish, and southern flounder. Sport crabbing and sport shrimping are also popular activities in the study area.

Table 4 provides a summary of the 1963-1978 average annual commercial landings and value of the major estuarine-dependent commercial fishes and shellfishes in and adjacent to the study area. As noted in Table 4, menhaden dominate the total poundage landed, while shrimp rank first in total value. Other commercially important species include blue crab, American oyster, Atlantic croaker, spotted seatrout, sand seatrout, spot, and red drum.

Table 3. Commercial harvest of catfish and bullheads from the Louisiana Portion of the study area, including landings by other states (1963-76)

Year	Thousands of pounds
1963	250.6
1964	176.5
1965	142.8
1966	96.6
1967	110.5
1968	87.0
1969	123.2
1970	96.1
1971	84.3
1972	40.8
1973	61.2
1974	25.5
1975	20.8
1976	39.0
14 Year Total	1354.9
14 Year Average	96.8

Table 4. Average annual commercial landings and value of major estuarine-dependent finfishes and shellfishes in and adjacent to the study area

Species	
Menhaden	
Landings[a]	51.85
Value[b]	3.11
Shrimp	
Adjusted Landings[c]	27.94
Value	31.02
Oyster	
Adjusted Landings[d]	11.05
Value	16.68
Croaker[e]	
Landings	1.83
Value	0.40
Blue Crab	
Landings	2.68
Value	0.88
Seatrout[e]	
Landings	0.47
Value	0.30
Spot[e]	
Landings	0.02
Value	-
Red Drum	
Landings	0.14
Value	0.06
Total	
Adjusted Landings	95.97
Value	52.46

SOURCE: National Marine Fisheries Service landing records for the years 1963-1978, compiled by New Orleans District, Corps of Engineers.

Continued

Table 4. Continued

a. Millions of pounds.

b. Millions of 1981 dollars. Value for all species except oysters represents running average of 1974-1978 exvessel prices brought to 1981 price levels using the Consumer Price Index for food. Average price for oysters calculated for period 1976-1980.

c. Reflects 200 percent increase of reported inshore landings, based on surveys conducted by Louisiana Department of Wildlife and Fisheries (C.J. White, personal communication, letter dated April 23, 1979).

d. Reflects 150 percent increase of reported landings, based on Mackin and Hopkins (1962) and Lindall et al. (1972).

e. Includes food fish and industrial bottomfish. Quantities of croaker, spot, and seatrout calculated after Lindall et al. (1972).

Detailed discussions on sport and commercial fishing in the study area are contained in the FWS planning aid report prepared for this study (1980). A wealth of information on the biology and harvest of the commercially important estuarine fishes and shellfishes of coastal Louisiana has been compiled in a report prepared by the National Marine Fisheries Service (Lindall et al. 1972).

Wildlife Resources

Because of the diversity and areal extent of productive habitat types in the study area, the area supports a wide variety of wildlife. These include game species, commercially important furbearers, endangered species, and other nongame species.

Game Species

Common migratory puddle ducks in the study area include mallard, green-winged teal, blue-winged teal, pintail, American wigeon, gadwall, and northern shoveler. These ducks reach highest concentrations in the fresh and intermediate marshes of the study area. Wood ducks nest in the wooded swamps and seasonally flooded bottomland hardwood forests of the study area, and additional migrants winter in these habitats. Mottled ducks nest in the fresh to saline marshes of the area.

Diving ducks which winter in the study area include ringnecked duck, lesser scaup, greater scaup, hooded merganser, redbreasted merganser, bufflehead, redhead, old squaw, ruddy duck, common golden eye, and canvasback. Diving ducks are generally most common in bays, sounds, and larger marsh ponds and lakes. Lakes Pontchartrain and Maurepas winter an estimated 500,000 lesser scaup (Tarver and Dugas 1973) and large concentrations of this species can also be found in Lake Borgne. According to Bellrose (1976), the coastal area between Mobile Bay and Louisiana winters an additional 17,000 lesser scaup. Bellrose also reported that the submerged grass beds of the Chandeleur Islands winter an estimated 20,000 redhead ducks annually.

The FWS, in cooperation with State fish and wildlife agencies and other knowledgeable personnel, has identified key privately-owned wetland areas along the Central Gulf Coast that are considered vital habitat for wintering waterfowl. It has been proposed that these key wetland areas be preserved with Migratory Bird Conservation Account Funds through easements and/or fee acquisition if other preservation methods are not available. Six of the 14 key wetland units identified along the Central Gulf Coast are located in the study area and are as follows: Delacroix, St. Charles, Lake Maurepas, Point Clear, Pascagoula Marsh, and Point Aux Chenes-Grand Bay Swamp Units.

The Delacroix Unit lies in St. Bernard and Plaquemines Parishes, Louisiana, and is bordered by Lake Borgne and the Mississippi River-Gulf Outlet on the northeast, Breton Sound to the southeast, and the Mississippi River levee on the southwest and northwest sides. The Delacroix Unit was once considered to be southeast Louisiana's most

productive fur and waterfowl marsh area, but now supports the smallest population of wintering waterfowl of all the key wetland areas in Louisiana. Between 1969 and 1978, this unit supported an average annual population of 19,200 wintering waterfowl. During the late 1950's, this area wintered more than 250,000 waterfowl annually. The major species utilizing this unit, in decreasing order of abundance, include American coot, gadwall, mottled duck, mallard, American wigeon, lesser scaup, green-winged teal, blue-winged teal, hooded merganser, shoveler, and pintail. The drastic decrease in wintering waterfowl in the Delacroix Unit during recent years is attributed to rapid conversion of fresh and intermediate marshes to brackish and saline marshes, much of it resulting from saltwater intrusion associated with construction of the Mississippi River-Gulf Outlet.

The St. Charles Unit lies in St. Charles Parish, Louisiana, and is bordered on the north by Lake Pontchartrain, on the south by U.S. Highway 61, on the west by the Bonnet Carre Floodway, and on the east by the St. Charles/Jefferson Parish boundary. This unit supports more than 25,000 ducks and 11,000 coots annually. The major species utilizing this unit include mallard, gadwall, American wigeon, lesser scaup, and American coot. The productivity of this unit is being threatened as the fresh and intermediate marshes are deteriorating into open water bodies due to saltwater intrusion. Freshwater introduction would allow this unit to remain productive waterfowl habitat.

The Lake Maurepas Unit lies in portions of St. John the Baptist, Tangipahoa, St. James, and Ascension Parishes, Louisiana. It is located along the northeastern, eastern, southern, and southwestern shores of Lake Maurepas. The unit is bordered on the east by the Tangipahoa River and western shore of Lake Pontchartrain, on the south by Interstate 10, on the west by Blind River and Interstate 55 and on the north by the T7S-T8S line. The wetlands in the unit are dominated by wooded swamp with scattered areas of fresh and intermediate marshes. This unit supports an estimated population of about 69,000 waterfowl and 30,000 coots annually. The major species utilizing this unit include mallard, gadwall, American wigeon, and American coot.

The Point Clear Unit occupies the southernmost portion of Hancock County, Mississippi, and is adjacent to the extreme northwestern portion of Mississippi Sound. Most of the unit consists of saline marsh. This unit supports an average annual wintering population of about 1,000 waterfowl and 200 American coots. The major species utilizing the area includes lesser scaup, redhead, ring-necked duck, and American coot.

The Pascagoula Marsh Unit spans an area of Jackson County, Mississippi between the East Pascagoula and the West Pascagoula Rivers and extends to the swamp edge to the north. Brackish and intermediate marshes comprise most of the unit. This unit supports an average annual wintering population of about 2,300 ducks and 200 American coots. The major species utilizing the area include wood duck, mallard, lesser scaup, ring-necked duck and American coot.

The Point Aux Chenes-Grand Bay Swamp Unit lies in extreme southeastern Jackson County, Mississippi, and extreme southwestern Mobile County, Alabama. The unit consists of mostly brackish and saline marshes and wooded swamp. This unit supports an average annual wintering population of more than 900 waterfowl and 100 American coot. The major species utilizing the area include mallard, American wigeon, redhead, lesser scaup, and American coot.

Lesser snow geese are the only geese that winter in the study area in significant numbers. These occur primarily in the brackish marshes of the study area, and are sometimes found on the barrier islands. Harvest records indicate that the dark color phase of this species, formerly called the blue goose, is more common in the area than the light phase.

Other game birds in the study area include rails, purple gallinule, common gallinule, American coot, common snipe, American woodcock, wild turkey, mourning dove, and bobwhite quail. Rails in the study area include king rail, clapper rail, sora, and Virginia rail. King rail and clapper rail nest and winter in the coastal marshes of the project area, while the Virginia rail and sora rail are considered to be winter residents. The American coot, a popular game bird with some waterfowl hunters, is primarily a winter resident of the fresh to brackish marshes. Scattered breeding of this species in the freshwater marshes of the area also occurs.

The common snipe winters in the fresh to brackish marshes and wet agricultural lands, while the American woodcock occurs primarily in seasonally flooded bottomlands. Resident mourning dove populations are present, but winter populations are much greater due to the influx of migrants from more northerly latitudes. Nesting occurs in a variety of habitats, such as orchards, forest edges, fence rows, riparian vegetation along small streams and drainage canals, churchyards, and other areas. Wintering dove populations feed heavily on agricultural lands supporting such crops as corn, rice, and soybeans. Some doves occur in association with the coastal marshes and forested wetlands. Bobwhite are primarily associated with areas supporting an interspersion of agricultural lands and forest edges. The wild turkey is present in the bottomland hardwood and pine forests along the northern side of Lakes Pontchartrain and Maurepas, and portions of the Mississippi coastal plain, and in the Pearl River bottomlands and swamps.

The white-tailed deer is the only big game mammal found in the study area. It is found in bottomland hardwood forests and wooded swamps, and also occurs in the coastal marshes, especially in the fresher marshes interspersed with higher ground.

Small game mammals present in the study area include swamp rabbit, Eastern cottontail, gray squirrel, fox squirrel, and raccoon. Swamp rabbits most commonly occur in the wooded swamps, bottomland hardwoods and fresh to brackish marshes of the study area. The eastern cottontail is most frequently found in association with pastures, row crop fields, along fence rows and drainage ditches, and forest edges.

Both the gray and fox squirrels occur in the wooded swamp and bottomland hardwood forests of the study area. The fox squirrel also is found in the adjacent mixed pine hardwood forests that border the northern edges of the study area. Raccoon are found in the wooded swamp and bottomland hardwood forests and also range into the coastal marshes of the study area.

Table 5 shows the estimated 1978 demand for sporting hunting in the marshes and wooded swamp within the Louisiana portion of the study area (the area to be affected by the tentatively selected freshwater diversion plan). As shown in that table, small game hunting is the most popular hunting activity.

Commercial Species

Commercially important furbearers in the study area include nutria, muskrat, mink, river otter, raccoon, striped skunk, bobcat, beaver, and opossum. Although frequently present in seasonally flooded bottomland hardwood forests and wooded swamps, both nutria and muskrat are most abundant in the coastal marshes. Nutria are most abundant in fresh marshes, while muskrat reach peak populations in brackish marshes where lush growths of Olney's threesquare are present. Mink are most common in the forested wetlands of the area. This species is also common in the coastal marshes, decreasing in abundance with increasing salinity levels. The river otter is found in association with forested wetlands, along streams, and in the coastal marshes. The raccoon is common throughout most wooded and marsh habitats of the study area, and has also been reported from the barrier islands. The opossum, bobcat, and beaver are primarily associated with the bottomland hardwood forests and wooded swamps of the area.

Fur harvest records are not available for the individual parishes and counties of the study area. However, Table 6 shows the estimated annual fur catch per 1,000 acres of specific wetland types, for muskrat, nutria, mink, raccoon, and river otter in the Louisiana coastal zone.

Because of changes in regulations developed pursuant to the Endangered Species Act of 1973, controlled sport and commercial hunting of the American alligator is now allowed in the Louisiana portion of the study area. Sale of hides and meat represent an important new source of income for local residents. The alligators in the Louisiana portion of the study area are classified as threatened under the Similarity of Appearance clause of the Endangered Species Act of 1973. Table 7 presents the value of the potential alligator harvest in the marsh and wooded swamp habitats of this portion of the study area.

Endangered Species

Several endangered species are found in the study area. Endangered birds known to occur in the area include the bald eagle, brown pelican, arctic peregrine falcon, red cockaded woodpecker, and Mississippi sandhill crane. The bald eagle occurs from the early fall to late spring in the marshes, lakes, and swamps. Recently active

Table 5. Estimated 1978 sport hunting use (man-days) in that portion of the study area which would be affected by the tentatively selected plan[a]

Hunting Type	
Deer	21,908
Small game	160,095
Waterfowl	83,686
Other migratory birds	36,849
Total	302,538

a. Data compiled by New Orleans District Corps of Engineers Recreation Section.

b. Primarily rabbit, squirrel, and bobwhite.

c. Primarily rails, snipe, dove, and woodcock.

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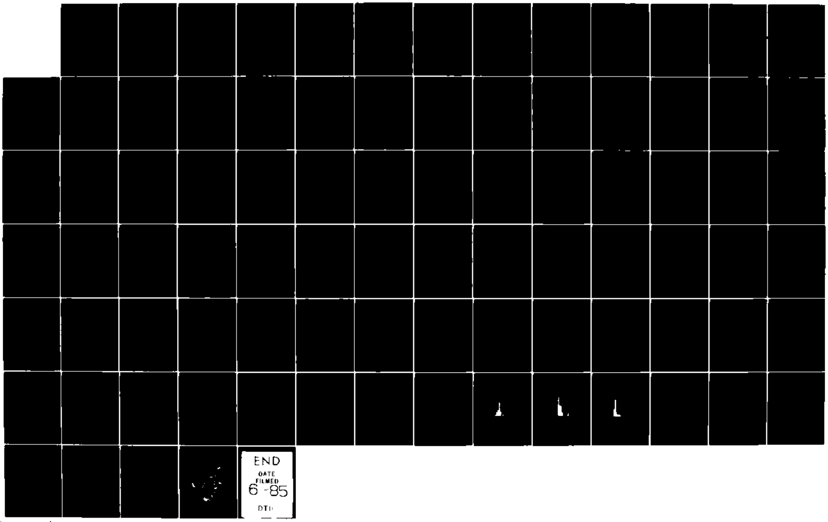

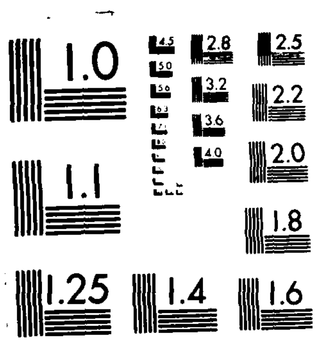

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Table 5. Fur catch and value by habitat type for coastal Louisiana

Species	Habitat Type Fresh-Intermediate Marsh	Brackish Marsh	Saline Marsh	Wooded Swamp
Muskrat				
Average catch/acre[a]	0.0880[b]	0.0844	0.0169	0.0273[d]
Value/pelt[e]	\$5.43	\$5.43	\$5.43	\$5.43
Value/acre	\$0.4778	\$0.4583	\$0.0918	\$0.1482
Nutria				
Average catch/acre	0.3988[b]	0.0864	insignificant	0.1995[d]
Value/pelt	\$7.39	\$7.39	-	\$7.39
Value/acre	\$2.9471	\$0.6385	insignificant	\$1.4743
Mink				
Average catch/acre	0.0015[b]	0.0011	insignificant	0.0216[d]
Value/pelt	\$13.67	\$13.67	-	\$13.67
Value/acre	\$0.0205	\$0.0150	insignificant	\$0.2953
Otter				
Average catch/acre	0.0005[b]	0.0002	insignificant	0.0005
Value/pelt	\$44.55	\$44.55	-	\$44.55
Value/acre	\$0.0223	\$0.0089	insignificant	\$0.0223
Raccoon				
Average catch/acre	0.0093[f]	0.0078[g]	insignificant	0.0984[h]
Value/pelt	\$11.46	\$11.46	-	\$11.46
Value/acre	\$0.1066	\$0.0894	insignificant	\$1.1277
Total				
Average catch/acre	0.4979	0.1799	0.0169	0.3473
Gross value/acre	\$3.5743	\$1.2101	\$0.0918	\$3.0678
Net value/acre[i]	\$2.6807	\$0.9076	\$0.0689	\$2.3009

Continued

Table 6. Continued

a. Averge catch per acre, unless otherwise noted, from Palmisano (1973).

b. Represents mean of fresh and intermediate marsh average harvest/acre reported by Palmisano (1973).

c. Calculated as 25 percent of brackish marsh average harvest/acre reported by Palmisano (1973).

d. Calculated as a percentage of fresh marsh average harvest/acre reported by Palmisano (1973), based on a comparison of the two habitat types by Nichols and Chabreck (1973).

e. Based on 1976-81 running average of prices received by the trapper, expressed in 1981 dollars using the Consumer Price Index for hides, skins, leather and related products. Base price data compiled by Louisiana Department of Wildlife and Fisheries.

f. Represents one half of the combined maximum production for fresh and intermediate marsh types reported by Palmisano (1973).

g. Represents one half the maximum value reported by Palmisano (1973).

h. Based on harvest projected by Nichols and Chabreck (1973).

i. Cost of harvest equals 25 percent of gross value; net value equals gross value minus cost of harvest.

Table 7. Value of potential alligator harvest by habitat type in the Louisiana portion of the study area[a]

	Habitat Type			
	Fresh-Intermediate Marsh	Brackish Marsh	Saline Marsh	Wooded Swamp
Mean harvest (hides)/acre	0.0057	0.0023	Negligible	0.0024
Mean value/hide[b]	$133.00	$133.00	N/A	$133.00
Mean value of meat/animal[c]	$71.40	$71.40	N/A	$71.40
Mean total value/animal	$204.40	$204.40	N/A	$204.40
Total value (gross)/acre	$1.17	$0.47	Negligible	$0.49
Net value (gross value less cost of harvest)/acre[d]	$0.88	$0.35	Negligible	$0.37

a. Data on hide value, mean hide length, mean weight, and harvest provided by Ted Joanen and David Richard, Louisiana Department of Wildlife and Fisheries, Grand Cheniere, Louisiana.

b. Based on mean length/hide of 7 feet and mean 1981-1982 hide price of $16.50 per linear foot.

c. Based on mean dressed weight/animal of 47.6 pounds and estimated 1982 mean price of $1.50 per pound.

d. Based on cost of harvest equal to 25 percent of total gross value.

nests have been confirmed near St. Rose and White Kitchen in St. Charles and St. Tammany Parishes, Louisiana, respectively. The brown pelican feeds in the shallow waters adjacent to the barrier islands. Recent attempts to re-establish a nesting colony of this species on the Chandeleur Islands have been successful. Surveys recently conducted by FWS biologists revealed approximately 500 brown pelicans and 150 nests in this area. The arctic peregrine falcon is an occasional visitor to the area marshes and barrier islands. The red cockaded woodpecker is found in mature pine stands of adjacent uplands.

The entire population of the Mississippi sandhill crane is limited to 40-50 individuals located in the coastal savannas of Jackson County, Mississippi. Much of the critical habitat used by these birds is now protected as part of the Mississippi Sandhill Crane National Wildlife Refuge, established in 1974.

Other endangered birds of doubtful occurrence in the study area include Bachman's warbler, Eskimo curlew, and ivory-billed woodpecker. None of these species have been confirmed from the study area in recent years. The only endangered land mammal which may occur in the forested bottomlands and wooded swamps is the Florida panther. Although recent sightings have been reported in both the Louisiana and Mississippi portions of the study area, few, if any, have been confirmed. Endangered marine mammals which may occur in the waters of the study area include blue whale, finback whale, humpback whale, sei whale, sperm whale, and West Indian manatee.

The American alligator remains on the U.S. Department of the Interior's list of endangered species in Mississippi. As noted earlier, alligators found in the Louisiana portion of the study area are now classified as "threatened" under the Similarity of Appearance clause of the Endangered Species Act of 1973 (Federal Register, June 25, 1979).

Sea turtles occur in the saline waters in or adjacent to the project area, and include Atlantic loggerhead, Atlantic ridley, Atlantic hawksbill, Atlantic leatherback, and Atlantic green turtles. The Atlantic ridley, Atlantic hawksbill, and Atlantic leatherback turtles are classified as endangered species, while the Atlantic loggerhead and Atlantic green turtles are considered threatened.

Other Non-Game Species

Numerous other non-game species are present in the study area. These include wading birds, seabirds, shorebirds, songbirds, raptors, land and marine mammals, and numerous reptiles and amphibians. Wading birds occur in the forested wetlands and marshes, and on barrier islands; seabirds are primarily associated with the brackish to saline open waters of the area, but also range into the marshes and barrier islands for feeding and nesting purposes. Common wading birds include great blue heron, little blue heron, tri-colored (Louisiana) heron, green heron, yellow-crowned night heron, black-crowned night heron, great egret, cattle egret, snowy egret, reddish egret, white-faced ibis, and white ibis. Seabirds present include brown pelican, white

pelican, ring-billed gull, herring gull, laughing gull, gull-billed tern, Forster's tern, common tern, sooty tern, least tern, sandwich tern, Caspian tern, royal tern, and black skimmer. The locations of recently active seabird and wading bird nesting concentrations in the study area have been listed in the previously submitted FWS planning aid report (1980). The marshes, barrier islands, and mainland beaches of the project area also provide habitat to numerous species of shorebirds, such as black-necked stilt, American oystercatcher, killdeer, black-bellied plover, willet, greater yellowlegs, lesser yellowlegs, sanderlings, and various other small sandpipers. Other non-game birds in the project area marshes include marsh hawk, long-billed marsh wren, belted kingfisher, red-winged blackbird, boat-tailed grackle, and seaside sparrow. The bottomland hardwood forests and wooded swamps of the project area support numerous non-game birds, such as blue jay, cardinal, tufted titmouse, Mississippi kite, barred owl, warblers, vireos, wrens, kinglets, and woodpeckers.

Non-game mammals in the project area are also numerous. The rice rat is common in the marshes. Typical non-game mammals in the forested portions of the study area include eastern wood rat, white-footed mouse, short-tailed shrew, and nine-banded armadillo. The Atlantic bottlenose dolphin is the most common marine mammal occurring in the open waters of the study area, found primarily in the bays, sounds, and tidal passes.

Amphibians are generally restricted to the freshwater marshes, ponds, stream and lake margins, and forested wetlands of the study area. The bullfrog and pig frog are important from a commercial and sporting standpoint. Other representative amphibians include lesser siren, Gulf Coast toad, oak toad, Fowler's toad, green treefrog, cricket frog, and bronze frog.

Reptiles present in the marshes and swamps include the American alligator, common snapping turtle, alligator snapping turtle, smooth softshell turtle, spiny softshell turtle, diamondback terrapin, red-eared turtle, stinkpot, green anole, broad-headed skink, diamondback water snake, banded water snake, Gulf salt marsh snake, and western cottonmouth. Of these, only the Gulf salt marsh snake and diamondback terrapin are common in the brackish to saline marshes.

EVALUATION METHODOLOGY

An analysis of the impacts of the tentatively selected freshwater diversion features on fish and wildlife reseources was performed in close cooperation with personnel of the NODCE Planning Division, LDWF, Mississippi Bureau of Marine Resources (MBMR), and the Gulf Coast Research Laboratory (GCRL). This analysis dealt with two major types of impacts, i.e., the direct impacts on wildlife habitat associated with construction and maintenance of the diversion structures and associated channels, and the effects of introducing supplemental fresh water, sediments, and nutrients on salinity levels and marsh loss in

the receiving area. An effort was made to quantify both monetary and non-monetary impacts of the proposed project on fish and wildlife resources.

The FWS's 1980 Habitat Evaluation Procedures (HEP) were utilized to assess project impacts (non-monetary) on wildlife habitat quality and quantity. The methodology and findings of the HEP analysis are found in Appendix A. Monetary impacts were assessed by predicting project effects on sport fishing, sport hunting, commercial fisheries, and commercial fur and alligator harvests. Details of the procedures followed for the economic analysis are described in Appendix B of this report and in Appendix F accompanying the feasibility report (FR) prepared for this project by the NODCE.

For both the economic and HEP analyses, the primary basis for determining project impacts was a comparison of habitat quality and quantity under with-project versus without-project conditions. The 50-year project life was assumed to extend from 1990 to 2040. Because the proposed diversion feature would affect the Louisiana and Mississippi portions of the study area differently, existing and anticipated future habitat acreages were estimated separately for each portion. Existing acreages (Tables 1 and 2) were derived from data developed by Wicker (1980) and stored in computers by the FWS's National Coastal Ecosystems Team in Slidell, Louisiana. Estimates of future without-project acreages were developed for selected major habitat types. These estimates were made for key target years spanning the 50-year project life, i.e., 1990 to 2040, and were based on the loss rates calculated from Wicker (1980) for the period 1955-56 through 1978. Estimates of acreages of specific habitat types to be directly affected by construction and maintenance of the diversion structure and associated conveyance channel were supplied by NODCE and utilized in our analyses. Project benefits to fish and wildlife were computed based on decreased marsh and wooded swamp loss, increased access facilities, and more favorable salinity conditions conducive to improved oyster production.

The introduction of supplemental fresh water as planned would reduce saltwater intrusion and associated deterioration of fresh and intermediate marshes, and would also introduce additional nutrients and sediments that would increase marsh plant growth and associated peat production and reduce subsidence rates. Estimates of project-related reductions in marsh and wooded swamp loss were developed jointly by FWS and NODCE personnel based on the results of several studies on the effects of river flooding or saltwater intrusion on affected wetlands. A detailed account of the methodology used to determine with-project and without-project habitat acres is contained in Appendix D accompanying the FR.

The proposed freshwater diversion would also restore optimal salinity conditions over large areas of prime, historically productive oyster bottoms in the western portion of Mississippi Sound and the Louisiana marshes east of the Mississippi River-Gulf Outlet. In order to quantify project benefits to oyster production, meetings were held between representatives of FWS and NODCE, and personnel from LDWF,

MBMR, and GCRL having special expertise in oyster biology. A detailed explanation of the methodology used to develop estimates of project-related increases in oyster production is contained in Appendixes D and F of the FR.

Field investigations of the study area were conducted by biologists with the FWS, NODCE, MBMR, and LDWF to gain additional information regarding habitat types and associated fish and wildlife use in the study area. Knowledge obtained during these investigations was supplemented by interpretation of available aerial photography and habitat maps prepared for the Fish and Wildlife Service's National Coastal Ecosystems Team by Wicker et al. (1980).

PROJECT IMPACTS

Habitat Impacts

Project impacts on fish and wildlife habitat quantity and quality can be divided into two major categories, i.e., habitat alteration associated with construction and maintenance of the diversion structure and associated channels, and impacts of the proposed freshwater diversion on the marshes, open waters and associated productivity of the receiving areas.

Construction and Maintenance Impacts

A summary of the construction and maintenance impacts of the diversion feature of the recommended plan is shown in Table 8. As shown in Table 8, the Bonnet Carre Spillway site will impact 618 acres of wooded swamp; 63 acres of borrow pit and open water; 1,078 acres of disturbed land; and 52 acres of residential areas and levee. The impacts, on fish and wildlife resources, of construction and maintenance activities associated with the diversion structure are viewed as minor compared with the anticipated impacts on the wetlands of the hydrologic units receiving the diverted waters. The greatest beneficial impacts associated with these diversions will be a reduction in the rate of wooded swamp and marsh loss and the restoration of a lower salinity regime in the portion of the study area impacted by saltwater intrusion. Vegetated wetlands to be benefitted by the planned diversion are limited to the Louisiana portion of the study area, where the fresh water will be diverted. These wetlands will be benefitted by reduced salinities and increased nutrient and sediment input. The annual salinity extremes which are thought to be responsible for the deterioration of wooded swamps in this area (Wicker et al. 1981) would be sufficiently reduced to eliminate this stress. Lowered salinity conditions have been shown to result in increased plant growth in the fresh-intermediate and brackish marshes (Palmisano 1971) and can be expected to result in increased plant species diversity in brackish marsh.

Fine-grained sediments, transported by inflowing fresh water into marshes, will settle on the marsh floor. As reported by Delaune et

Table 8. Acreage of specific habitat types to be affected by construction and spoil disposal at the proposed freshwater diversion site

Project Feature	Habitat Acres			
	Wooded Swamp	Borrow Pit/ Open Water	Disturbed Land	Residential Area/Levee
Inflow channel	0	0	0	10
Diversion structure	0	0	0	5
Outfall channel	130	63	131	37
Disposal areas	488	0	947	0
Total	618	63	1078	52

al. (1978), the entrapment and stabilization of suspended inorganic sediment by marsh vegetation is an important process which helps to maintain elevation with respect to sea level, i.e., helping to offset subsidence. Delaune et al. (1978) also noted that the incoming sediment also supplies nutrients for plants which subsequently enhance further entrapment and stabilization of sediments. Artificial enrichment of several species of marsh plants in coastal Louisiana with wastewater from a menhaden processing plant increased the growth of those plants by 30 to 51 percent (Payonk, 1975). Increased plant production associated with increased nutrient inflow also contributes to peat formation. Thus, maintenance of a viable marsh is accomplished by the aggradational process of plant growth, accumulation of detritus, and inorganic deposition. Baumann and Adams (1982) measured the results of Atchafalaya River overbank flow on adjacent deteriorating marshes following major river flooding and showed this overbank flow to be responsible for reducing and in some cases reversing the deterioration process.

Tables 9 and 10 provide a comparison of future without-project (FWOP) and future with-project (FWP) acreages for the major vegetated wetland habitat types in the Mississippi and Louisiana portions of the study area, respectively. The fresh and intermediate marsh types were combined into the fresh-intermediate category because of the similarity of wildlife productivity of these two types. As shown in Table 9, acreages of all habitat types in the Mississippi portion of the study area will decline over the project life except wooded swamp. The proposed freshwater diversion will not significantly impact the wetlands in this area as shown in the table. The diversion would only alter water salinities in the extreme western part of Mississippi Sound which are influenced primarily by Pearl River and Mississippi Sound hydrological conditions.

In the Louisiana portion of the study area, the proposed freshwater diversion will affect wooded swamp, fresh-intermediate marsh, and brackish marsh acreages. Because of the distance of saline marshes from the diversion site and because of the close proximity of this marsh type to the saline waters of Chandeleur Sound, the freshwater diversion as proposed is expected to have little effect on saline marsh in Louisiana.

Bottomland hardwood forest in this area also would not be affected by the proposed diversion because of its more inland location and slightly higher elevation than the other wetland types. This forest type is influenced more by riverine hydrological conditions and upland runoff than estuarine hydrological conditions.

Wooded swamp will decline from nearly 133,100 acres in 1990 to about 69,500 acres by the year 2040, a reduction of nearly 48 percent. With the proposed diversion, wooded swamp will encompass approximately 75,900 acres by the year 2040. Fresh-intermediate marsh will decline from about 54,300 acres in 1990 to nearly 40,200 acres by the year 2040 under FWOP conditions. However, with the proposed diversion, fresh-intermediate marsh will increase to 55,500 acres by the year

Table 9. Comparison of future without-project (FWOP) and future with-project (FWP) acreages of bottomland hardwoods (BLH), wooded swamp (WS), and fresh-intermediate (F-IM), brackish (BM), and saline marsh (SM) in the Mississippi portion of the study area

Target Year		BLH	WS	F-IM	BM	SM	Total Marsh
1978 (Baseline)		42,394	33,162	19,885	19,942	27,325	67,152
1990	FWOP	41,637	33,162	18,575	19,515	26,580	64,670
	FWP	41,637	33,162	18,575	19,515	26,580	64,670
2000	FWOP	41,017	33,162	17,633	19,167	25,975	62,775
	FWP	41,017	33,162	17,633	19,167	25,975	62,775
2010	FWOP	40,406	33,162	16,802	18,825	25,384	61,011
	FWP	40,406	33,162	16,802	18,825	25,384	61,011
2020	FWOP	39,804	33,162	16,061	18,489	24,806	59,356
	FWP	39,804	33,162	16,061	18,489	24,806	59,356
2030	FWOP	39,210	33,162	15,397	18,159	24,241	57,797
	FWP	39,210	33,162	15,397	18,159	24,241	57,797
2040	FWOP	38,626	33,162	14,795	17,834	23,690	56,319
	FWP	38,626	33,162	14,795	17,834	23,690	56,319
Annualized							
	FWOP	40,114	33,162	16,516	18,663	25,108	60,287
	FWP	40,114	33,162	16,516	18,663	25,108	60,287
Net Change		0	0	0	0	0	0

Table 10. Comparison of future without-project (FWOP) and future with-project (FWP) acreages of bottomland hardwoods (BLH), wooded swamp (WS), and fresh-intermediate, (F-IM), brackish (BM), and saline marsh (SM) in the Louisiana portion of the study area

Target Year		BLH	WS	F-IM	BM	SM	Total Marsh
1978(Baseline)		48,338	155,507	58,346	137,662	56,386	252,394
1990	FWOP	45,516	133,071	54,282	129,626	50,223	234,131
	FWP	45,516	133,071	54,282	129,626	50,223	234,131
2000	FWOP	43,291	116,868	51,111	123,288	45,604	220,003
	FWP	43,291	118,488	55,513	119,740	45,604	220,857
2010	FWOP	41,174	102,638	48,126	117,261	41,411	206,798
	FWP	41,174	105,681	52,646	114,496	41,411	208,553
2020	FWOP	39,161	90,140	45,315	111,528	37,603	194,446
	FWP	39,161	94,433	49,944	109,508	37,603	197,055
2030	FWOP	37,247	79,164	42,668	106,075	34,145	182,888
	FWP	37,247	84,555	47,400	104,763	34,145	186,308
2040	FWOP	35,426	69,525	40,177	100,889	31,005	172,071
	FWP	35,426	75,880	45,001	100,251	31,005	176,257
Annualized							
	FWOP	40,269	98,022	46,890	114,682	39,875	201,447
	FWP	40,269	101,527	51,029	112,689	39,875	203,593
Net Change		0	+3,505	+4,139	-1,993	0	+2,146

2000 and then gradually decline to 45,000 acres by the year 2040. This increase would result from brackish marsh conversion to fresh-intermediate marsh near the diversion site. Under FWOP conditions, brackish marsh will decline from 129,600 acres in 1990 to 100,900 acres by the year 2040. With the proposed diversion, brackish marsh will decline to nearly 100,300 acres. The larger decline of brackish marsh under FWP conditions is a result of conversion of this marsh type to fresh-intermediate marsh in the vicinity of the diversion site. On an annualized (average annual) basis, the proposed diversion will increase wooded swamp and fresh-intermediate marsh by 3,500 and 4,100 acres respectively and reduce brackish marsh by 2,000 acres, compared to FWOP conditions.

Fisheries Impacts

A wealth of information has been compiled by the National Marine Fisheries Service (Lindall et al. 1972) and FWS (1980, 1983) which shows that low to moderate salinity regimes provide optimal conditions for at least some life stages of most estuarine fish and shellfish species harvested in the study area. The proposed diversion would result in an expanded low to moderate salinity zone in the Lake Pontchartrain Basin, the inland portion of Chandeleur Sound, and the western portion of Mississippi Sound. Generally, average salinities in these areas would be reduced by about 2 parts per thousand during the spring, summer, and fall and would be similar to historical conditions. This historic regime was partialy responsible for the high yields of oysters and other commercially valuable estuarine species prior to construction of the Mississippi River-Gulf Outlet.

As noted earlier, the proposed diversion would also result in reduced wetland losses and increased nutrient levels in area waters. The marshes of the study area provide essential spawning, feeding, and nursery habitat to the bulk of its commercially important fishes and shellfishes. In addition, marshes and wooded swamps contribute plant detritus, a vital component of the estuarine food chain, to adjacent waters. Thus the proposed diversion would benefit fisheries by reducing wetland loss, expanding the low to moderate salinity zone, and increasing nutrient levels in affected waters.

At the time project impacts were determined, the HEP had not been finalized for application in assessing project impacts on fish and shellfish habitats. However, an analysis of the proposed project features on the monetary value of sport and commercial fishing was conducted; this analysis is contained in Appendix B. As discussed in that appendix, there is growing evidence that the acreage of marsh is the most important factor influencing the production of estuarine-dependent species of sport and commercial importance in the Gulf area. Therefore, the project-related reduction in wetland loss was used as the primary basis for estimating project benefits to fishery resources, with the exception of oyster production. Benefits to oyster production were based on restoration of optimal salinity conditions over historically productive oyster bottoms. A summary of project-related changes in the magnitude and value of sport and commercial fishery resources is displayed in Table 11. Additional

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is expected to include such items as water quality (e.g., salinity, nutrient levels, water temperature, turbidity, etc.), vegetation patterns, wildlife population enumeration, and contaminant levels in selected fish and wildlife species. Extensive sampling programs are already carried out by state and local agencies; therefore, overall coordination of these programs may achieve many of the monitoring objectives.

RECOMMENDATIONS

Based on a review of the tentatively selected plan for providing supplemental fresh water into the Chandeleur Sound and Mississippi Sound basins, the FWS recommends that the following measures be implemented in the interest of fish and wildlife conservation:

1. The tentatively selected plan be recommended for authorization in the final feasibility report and

2. The final feasibility report request authority for funding of post-authorization studies to include participation of the FWS, National Marine Fisheries Service, LDWF, MBMR, and the Louisiana Department of Natural Resources (Coastal Management Section) in the design of the proposed structures, the development of operational and maintenance guidelines, and the design of monitoring studies of the affected area.

first line of defense against hurricanes by serving to buffer the adjacent mainlands from storm-driven waves. Marshes and swamps also perform an important water quality function by removing excess nutrients from associated water bodies, thus helping to reduce water quality problems caused by eutrophication.

As noted earlier, the Central Gulf Coast wetlands are of national importance to migratory waterfowl. Data compiled by the FWS reveal that 20 to 25 percent of all the migratory puddle ducks in North America winter in Louisiana's coastal wetlands. These wetlands, which include those in the study area, also provide temporary habitat to ducks and other waterfowl which winter in Central and South America. This reduction in the rate of loss of productive marshes and swamps should, therefore, substantially benefit an important international resource.

The proposed discharge of sediment-laden Mississippi River water is expected to result in the formation of a relatively small delta in Lake Pontchartrain, at the mouth of the proposed diversion channel. Such deltaic areas are highly productive for numerous fish and wildlife species and the development of such an area would help to address the alarming problem of coastal wetlands loss.

DISCUSSION

It is clear from the preceding section that the tentatively selected plan will have major beneficial impacts on fish, wildlife, and related resources. The concept of re-introducing fresh water from the Mississippi River into adjacent estuaries is not a new one. For years, the FWS has actively advocated this concept, which would partially mitigate fish and wildlife damages caused by the Federally constructed Mississippi River mainline levees. The presently proposed diversion would also reduce the degradation of fish and wildlife habitats associated with the construction and maintenance of the Mississippi River-Gulf Outlet.

Under the tentatively selected plan, operation and maintenance of the proposed structures would be a non-Federal responsibility. No specific division of this responsibility has yet been determined by the States of Louisiana and Mississippi or the local governing bodies which would be directly affected by the project. Because the proposed structures would be operated for the specific benefit of fish and wildlife resources, it would seem that the LDWF and MBMR (possibly with assistance from the Louisiana Office of Public Works) would be the most logical candidates for that task. Specific operational guidelines would be developed during the design stages, and should include broad input from Federal, State, and local agencies having expertise in such fields as fish and wildlife management, flood control, and public health.

The tentatively selected plan includes a monitoring program to gauge the effectiveness of the proposed diversion. The monitoring program

minimize adverse effects on fishery resources. It is anticipated that brown shrimp production in Lake Pontchartrain would be adversely impacted by the proposed diversion, as this area represents the inland extent of their nursery use under average conditions. Research conducted by the LDWF has revealed that water temperature and salinity in early spring are the critical factors influencing brown shrimp production in Louisiana estuaries (White and Boudreaux 1977). With the proposed diversion, water temperature and salinity would be reduced slightly during that period, whereas higher salinity and water temperature would favor increased survival and growth of juvenile brown shrimp. To minimize this impact, freshwater flows could be discharged at low rates initially and then be gradually increased to allow aquatic organisms such as brown shrimp to acclimate to the lower water salinity and temperature.

It is anticipated that reduced salinity in the northwestern lobe of Lake Borgne will render the area too fresh for sustained commercial oyster production. As with brown shrimp in Lake Pontchartrain, this area represents the inland extent of oyster production and is now only marginally suited for sustained commercial production. With the proposed diversion, the zone of optimal oyster production in the study area will be expanded and stabilized; the resulting overall increase in production will more than compensate for the loss of production in Lake Borgne.

Fecal coliform bacteria density is used as an indicator of contamination by other human pathogenic bacteria and viruses. Fecal coliform concentrations usually exceed EPA criteria in both the Mississippi River and Lake Pontchartrain. Thus, no significant change in this aspect of water quality is anticipated with freshwater diversion.
Oyster production areas in the northwestern portion of Lake Borgne are occasionally closed to harvesting by public health authorities because of excessive coliform concentrations. These areas were established following the drastic salinity increases which occured after excavation of the Mississippi River-Gulf Outlet in the 1960's; this inland shift in oyster production placed those areas in close proximity to sources of high coliform concentrations. With the proposed diversion, the optimal zone of oyster production will be shifted seaward, i.e., farther away from pollution sources. Futhermore, the proposed diversion would expand the low-salinity zone between the Bonnet Carre Spillway and the more brackish zone, thereby increasing the distance between the spillway and estuarine-dependent organisms such as oysters. As a result, spillway operation during flood periods should have considerably less adverse effects on estuarine-dependent fisheries.

Non-quantifiable Impacts

In addition to those benefits quantified above, the reduction in the rate of wetland loss associated with the proposed freshwater introduction will have beneficial impacts that have not been quantified.

Marshes and swamps perform a variety of functions, in addition to providing habitat for fish and wildlilfe. These wetlands act as a

of the proposed action on water quality in the study area, is contained in Appendix H accompanying the FR prepared by NODCE. However, this section contains a discussion of some of those water quality issues of greatest potential concern with respect to fish and wildlife resources and associated human uses.

One major concern is the possible increase in pollutants introduced, via diverted Mississippi River water, into the study area water bodies, especially Lake Pontchartrain. Those types of pollutants of greatest concern are pesticides, polychlorinated biphenyls (PCB's), heavy metals, and substances such as phenolic compounds that cause "off" flavors in fishes consumed by humans. A number of pesticides were frequently detected in water samples taken in the lower Mississippi River below St. Francisville, Louisiana, according to data presented by Wells (1980). When pesticides were detected, their concentrations were often above maximum levels recommended by the Environmental Protection Agency (EPA) for protection of aquatic life. However, the diversion of Mississippi River water into Lake Pontchartrain and adjacent water bodies is not expected to result in fishes and shellfishes in those waters being unsafe for human consumption because of a buildup of pesticides, heavy metals, and "off" flavors in these organisms. The FWS measured concentrations of several pesticides, PCB's, and heavy metals in fishes taken from the Mississippi River at Luling, Louisiana, during 1969-1979. Average tissue concentrations of the pollutants measured did not exceed recommended maximum safe concentrations established by the Food and Drug Administration.

The development of "off" flavors in fishes taken from the Mississippi River below Baton Rouge, Louisiana was a serious problem in the early 1970's. Phenolic compounds are the primary substances which cause this tainting of fish flesh. However, an apparent decline in this problem is revealed by records of commercial landings of catfish and bullheads for the Mississippi River below the Bonnet Carre Spillway. Records compiled by the National Marine Fisheries Service reveal the average landings for the period 1974 through 1978 was eight times the average landings for the period 1964 through 1972. It is quite possible that these increased landings are a result of reduced concentrations of phenolic compounds in the lower Mississippi River, caused by more stringent control of industrial discharges of these and other pollutants. Many of the pollutants detected in samples from the Mississippi River have also been detected in samples from Lake Pontchartrain. Sikora and Sikora (1982) discussed the polluted conditions in Lake Pontchartrain in an ecological characterization of the lake bottom and indicated that areas in the lake receiving urban, industrial, and/or agricultural runoff are the primary polluted areas. As with the Mississippi River, many of the pollutant concentrations exceeded the EPA criteria.

Although the basic freshwater diversion scheme has been determined, the timing and duration of freshwater discharges must be designed to

Table 16. Comparison of Average Annual Habitat Units (AAHU) under future without-project (FWOP) and future with-project (FWP) conditions in marshes and wooded swamp influenced by the proposed freshwater diversion

Evaluation Elements	AAHU-FWP	AAHU-FWOP	Change in AAHU
Nutria	103,552	99,283	+4,269
Muskrat	161,307	158,530	+2,777
Puddle Ducks	87,739	83,770	+3,969
Alligator	97,731	94,341	+3,390

Table 15. Comparison of Average Annual Habitat Units (AAHU) under future without-project (FWOP) and future with-project (FWP) conditions

Evaluation Elements	AAHU-FWP	AAHU-FWOP	Change in AAHU
Herons, Egrets, and Ibises	619.08	624.16	-5.08
Swamp Rabbit	1211.16	1372.16	-161.00
Raccoon	920.05	975.02	-54.97
Wood Duck	619.08	624.16	-5.08
Barred Owl	439.92	453.46	-13.54
White-Tailed Deer	195.27	360.67	-165.40

Table 14. Projected net value of commercial wildlife harvest under future without-project (FWOP) and future with-project (FWP) conditions in the portion of the study area to be affected by the proposed diversion[a]

Harvest Type	(thousands of dollars)			
	1990	Annualized FWOP	Annualized FWP	Net Change
Fur animals	573	458	475	17
Alligators	142	118	122	4
Total	715	576	597	21

[a] From Table B-10, Appendix B

Table 13. Projected sport hunting use (man-days) under future without-project (FWOP) and future with-project (FWP) conditions in the portion of the study area to be affected by the proposed diversion[a]

Hunting Type	Hunting use (man-days)			
	1990	Annualized FWOP	Annualized FWP	Net Change
Big game	18,873	14,102	14,678	+576
Small game	139,259	106,226	109,632	+3,406
Waterfowl	78,266	68,369	69,686	+1,317
Other migratory birds	34,575	30,374	30,779	+405

[a]From Table B-7, Appendix B

Table 12. Projected wildlife populations under future without-project (FWOP) and future with-project (FWP) conditions in the portion of the study area to be affected by the proposed diversion[a]

Species	1990	Number of animals		
		Anualized FWOP	Annualized FWP	Net Change
Deer	2,425	1,807	1,879	+72
Rabbit	145,526	118,329	121,354	+3,025
Mottled Ducks[b]	1,319	1,155	1,191	+36
Wood Ducks[b]	1,464	1,078	1,117	+39

[a]From Table B-6, Appendix B.

[b]Represent estimated number of breeding pairs.

observations, we believe that similar fisheries will develop at the proposed structure, providing additional but presently unquantified economic returns.

Wildlife Impacts

A summary of the anticipated FWP and FWOP changes in wildlife populations in the wooded swamp and marshes to be affected by the proposed diversion is contained in Table 12. As shown in that table, the proposed diversion will lead to an annualized (average annual) increase of 72 white-tailed deer; 3,025 swamp rabbits; 36 breeding pairs of mottled ducks; and 39 breeding pairs of wood ducks, compared to FWOP conditions.

The expected FWP and FWOP changes in sport hunting use in the study area are summarized in Table 13. As shown in that table, the proposed diversion will result in an annualized increase of 576 man-days of big game hunting; 3,406 man-days of small game hunting; 1,317 man-days of waterfowl hunting; and 405 man-days of other migratory bird hunting, compared to FWOP conditions.

The expected changes in the net value of commercially important fur animals and alligators harvested in the affected portion of the study area are summarized in Table 14. That table shows a projected annualized increase of $17,000 in fur animal harvest and $4,000 alligator harvest under FWP conditions, compared to FWOP conditions.

The results of the HEP analysis (Appendix A) are summarized in Tables 15 and 16. Table 15 displays the impacts of construction and maintenance activities on selected wildlife species at the diversion site. Average Annual Habitat Units (AAHU's) are the basic units of measure in describing changes in habitat quality and quantity associated with a proposed action. As shown in Table 15, the changes in AAHU's to be caused by construction and maintenance activities are relatively minor. Reductions in AAHU's will be experienced by herons, egrets, and ibises; swamp rabbit; raccoon; wood duck; barred owl; and white-tailed deer.

Table 16 summarizes the changes in AAHU's for nutria, muskrat, puddle ducks, and alligator in the wetlands to be influenced by freshwater diversion. The relatively large gain in AAHU's expected for each of these evaluation species is an excellent indicator of the beneficial aspects of the proposed diversion on wildlife.

Both the FWS and National Marine Fisheries Service have indicated, by letters dated June 18, 1981, to the NODCE Planning Division Chief that no endangered or threatened species would likely be affected by the proposed freshwater diversion. In addition, the FWS noted that project-reduced salinities in Lake Maurepas and the surrounding wetlands may benefit bald eagles nesting in the area.

Water Quality

A detailed discussion of existing water quality in the Mississippi River and the adjacent receiving waters, as well as potential impacts

potential benefits associated with the proposed diversion are identified in the attached letter from the National Marine Fisheries Service.

Studies conducted by the NODCE Recreation Planning Section aggregated freshwater and saltwater sportfishing into a single sportfishing category. Personnel of that section have determined that, because the inadequate access to sprotfishing areas is not projected to be alleviated over the period of analysis (1990 to 2040), sportfishing effort will remain at the present level throughout that period. In other words, sprotfishing use in the study area will be stable at 1,823,000 man-days per year throughout the FWOP condition. However, the tentatively selected plan includes construction of additional access facilities. This increased access, combined with increased fish production associated with improved habitat conditions will result in an annualized increase of 98,000 man-days of sportfishing. As a result, the average annual value of sportfishing is projected to increase by $411,000 under FWP conditions.

Because freshwater commercial fisheries account for less than one percent of the total commercial fishery harvest in the study area, quantitative estimates of project impacts on commercial fisheries were not developed. However, it should be noted that the increase in fresh-intermediate marsh and associated water acreage under FWP conditions in Lake Maurepas and the western portion of Lake Pontchartrain should serve to increase freshwater commercial fish harvest, particularly for species such as blue catfish and channel catfish (van Beek et al. 1982).

Because of reductions in habitat loss and the creation of more favorable salinity conditions, the project is expected to substantially benefit estuarine-dependent commercial fishery resources. Details regarding the analysis of project impacts on estuarine-dependent commercial fisheries is contained in Appendix B. Under FWP conditions, the average annual harvest of shrimp, menhaden, and other finfishes and crustaceans dependent on the study area will exceed the average annual FWOP harvest of these species by 716,000 pounds, having a net value (gross value minus cost of harvest) of $59,000.

Oyster harvest in the study area is expected to remain at 8.0 million pounds annually under FWOP conditions. With the proposed freshwater diversion, potential harvest is expected to increase to 15.5 million pounds annually. NODCE economists estimated annual oyster fishery benefits to range from $4.3 to $8.1 million, depending on market conditions, and to average $6.5 million.

A substantial fishery for gizzard shad (important as crab and crawfish bait) and possibly other species such as blue catfish is expected to develop at the proposed discharge site. Commercial fishermen presently take large quantities of gizzard shad from the tailwaters of the Bayou Lamoque Diversion Structure located along the Mississippi River near mile 33.1 AHP. Blue catfish are also reportedly taken in large numbers immediately downstream from this structure. Based on these

Table 11. Estimated net annualized sport and commercial fishing benefits in the study area

Activity	
Sport fishing [a]	
man-days	98,000
value ($)	411,000
Commercial fishing harvest excluding oyster harvest [b]	
pounds	716,000
net value ($)	59,000
Commercial oyster harvest [b]	
pounds	7,500,000
net value ($)	6,500,000

[a] From Table B-2, Appendix B

[b] From Table B-11, Appendix B

MISSISSIPPI AND LOUISIANA

ESTUARINE AREAS STUDY

APPENDIX A

HABITAT EVALUATION PROCEDURES

ANALYSIS OF

TENTATIVELY SELECTED PLAN

The Habitat Evaluation Procedures (HEP) were developed by the Fish and Wildlife Service (FWS) to provide a method for describing baseline habitat conditions and predicting future habitat conditions in terms of habitat quality and quantity. This system is based on the assumption that all habitat has inherent value to wildlife and that impacts to wildlife habitat, the terms of modifications in quality and quantity, can be measured and compared.

In implementing the HEP (1980 version), a representative list of species or species groups is selected for the project area, and these species are used as evaluation elements in determining habitat quality. The habitat suitability of each of the evaluation elements is rated between 0 and 1, with 0 being the poorest and 1 being the optimal score. The scores for all sample plots within a particular habitat type are averaged for each evaluation element, and the resulting number is called the Habitat Suitability Index (HSI) for that evaluation element in that habitat type. A weighted average HSI must be derived for those species which are evaluated in more than one cover type. The HSI for each evaluation element (species) is then multiplied by the total area (acres) of available habitat to determine the total number of Habitat Units(HU's). HU's are the product of quality (HSI) and quantity (area) of the habitat for a particular species, and provide a standardized basis for comparing habitat changes over time and space.

The HEP analysis for this project was performed during May and June 1983. The FWS maintained a lead role in the analysis, with assistance from biologists of the Louisiana Department of Wildlife and Fisheries (LDWF) and the New Orleans District, Corps of Engineers (NODCE). The HEP analysis was divided into two main segments, i.e., the area to be impacted by construction and maintenance of the proposed diversion structures and associated inflow and outflow channels, and the fresh-intermediate, brackish and saline marshes to be affected by the proposed supplemental introduction of fresh water. Details regarding the methodology employed in the analysis of these two segments are contained below.

Construction and Maintenance Impacts

Field sampling was conducted at sites within specific habitat types to be impacted by structure installation, dredging, and spoil disposal. Table A-1 provides listing of habitat (cover) types visited at the tentatively selected diversion site, the number of sample sites visited within each habitat type sampled, and the evaluation elements rated within each habitat type. The small number of sample sites visited is a reflection of difficulty of access. Three habitat types, comprising 97 percent of the impact area, are located within the Bonnet Carre Spillway; the spillway was in operation during the field sampling period. The habitats sampled included woodedswamp, disturbed areas, borrow pit/lake front, and residential/levee. The wooded swamp habitat is located in the spillway and consists of an immature second growth forested wetland with an overstory composed of the following species: baldcypress, tupelogum, Drummond red maple, ash, black willow, cottonwood, sycamore, hackberry, and bitter pecan. The disturbed area habitat is also located in the spillway and consists of

an irregularly flooded grass/shrub zone with numerous sand mining pits, unimproved roads, and trails. Sand mining, cattle grazing, mowing, spillway operation, and off-road recreational vehicle use collectively prevent this zone from succeeding to a forested habitat type. The borrow pit/lake front habitat consists of a borrow canal in the spillway and a portion of Lake Pontchartrain adjacent to the spillway. The borrow canal is a deep, 200 to 300 foot-wide, 3 mile-long canal bordered by wooded swamp and is connected to Lake Pontchartrain. The lake front portion of this habitat type consists of the shallow open water area along a 0.5-mile-wide section of the forested lake shore. The residential/levee habitat consists of a residential area and a 0.75-mile length of Mississippi River and spillway levee, located immediately upstream from the spillway. The residential area consists of closely spaced houses, a baseball field and recreational area, streets and roads, a pasture, and a relatively small wooded area. The levees are maintained in a grassy state and are bordered by the residential area described above and wooded batture lands.

As shown in Table A-1, a total of six evaluation elements was rated for the diversion site. These included herons, egrets and ibises; swamp rabbit; raccoon; wood duck; barred owl; and white-tailed deer. The specieswereselected on the basis of their recreational, commercial,or public interest value and because they were considered representative of the faunal communities associated with the project area cover types. Table A-2 displays the mean HSI's of the various cover types, by evaluation elements, for the diversion site.

Estimates of the acreage of various cover types present in the area of construction impacts in 1978 and projected to occur at specific intervals (target years) under both future without-project (FWOP) and future with-project (FWP) conditions over the period of analysis (1990 - 2040) are shown in Table A-3. Estimates of FWOP rates of change in specific cover types were based on a projected continuation of land use trends in the spillway. It was assumed that the affected developed areas adjacent to the spillway would remain developed under FWOP conditions.

Table A-4 shows the net annualized change in HU's for the various evaluation elements. Since the affected areawould be converted to habitats of lower value, declines in AAHU's are predicted for all evaluation elements. Declines in AAHU's to be experienced by element are as follows: herons, egrets, and ibises (-5); swamp rabbit (-161); raccoon (-55); wood duck (-5); barred owl (-14); and white-tailed deer (-165).

Table A-1. Evaluation elements, cover types[a] and number of sample plots evaluated at the diversion site

Evaluation elements	WS	D	BP/LF	R/L
Herons, Egrets, and Ibises	1	1	1	0
Swamp Rabbit	1	1	1	1
Raccoon	1	1	1	1
Wood Duck	1	1	1	0
Barred Owl	1	1	1	1
White-Tailed Deer	1	1	1	0

[a]Cover type abbreviations: WS, wooded swamp; D, disturbed; BP/LF, borrow pit/lake front; R/L, residential /levee.

Table A-2. Mean Habitat Suitability Index (HSI), by evaluation element, for cover types[a] at the diversion site

Evaluation elements	WS	D	BP/LF	R/L
Herons, Egrets, and Ibises	0.30	0.40	0.12	-
Swamp Rabbit	0.80	0.80	0.12	0.15
Raccoon	0.50	0.60	0.14	0.20
Wood Duck	0.30	0.40	0.12	-
Barred Owl	0.20	0.30	0.02	0.10
White-Tailed Deer	0.40	0.10	0.09	-

[a]See Table A-1 for cover type abbreviations

Table A-3. Comparison of future without-project (FWOP) and future with-project (FWP) habitat acreage by cover type[a] for the diversion site

Target year		WS	D	BP/LF	R/L
1990	FWOP	618	1078	63	52
	FWP	618	1078	63	52
2000	FWOP	618	1078	63	52
	FWP	0	1435	371	5
2010	FWOP	618	1078	63	52
	FWP	0	1435	371	5
2020	FWOP	618	1078	63	52
	FWP	0	1435	371	5
2030	FWOP	618	1078	63	52
	FWP	0	1435	371	5
2040	FWOP	618	1078	63	52
	FWP	0	1435	371	5

[a]See Table A-1 for cover type abbreviations

Table A-4. Comparison of Average Annual Habitat Units (AAHU) under future without-project (FWOP) and future with-project (FWP) conditions at diversion site

Evaluation Elements	AAHU-FWP	AAHU-FWOP	Change in AAHU
Herons, Egrets, and Ibises	619.08	624.16	- 5.08
Swamp Rabbit	1211.16	1372.16	-161.00
Raccoon	920.05	975.02	- 54.97
Wood Duck	619.08	624.16	- 5.08
Barred Owl	439.92	453.46	- 13.54
White-Tailed Deer	195.27	360.67	-165.40

Impact of Freshwater Diversion on Receiving Area

As previously noted, the HEP were used to help quantify anticipated impacts of supplemental freshwater introduction on the marshes and wooded swamp of the study area. The most significant impact is expected to be a reduction in the rate of land loss and saltwater intrusion that would have occurred without freshwater introduction. As discussed in the main report, this reduction in wetland deterioration is based on increased sediment and nutrient input, and reduced salinities. Table A-5 provides a comparison of FWOP and FWP marsh and swamp acres in the Louisiana portion of the study area. Freshwater diversion will have little effect on marshes and swamp in the Mississippi portion of the study area. Therefore, this evaluation is restricted to the Louisiana portion of the study area. A smaller acreage of brackish marsh was projected under FWP conditions because a portion of this marsh type occurs adjacent to the freshwater discharge site and would be converted to fresh-intermediate marsh. No relative change was projected for saline marsh under FWP conditions because salinities would notbe reduced for a sufficient duration because of the distance of saline marshes from the discharge site (60-80 miles), and because of the close proximity of this marsh type to the high salinity waters of Chandeleur Sound.

In order to quantify the impact of these acreage changes on wildlife, HSI's were assigned to wooded swamp and fresh/intermediate, brackish, and saline marsh for a list of evaluation elements common to all habitat types, i.e., American alligator, migratory puddle ducks, muskrat, and nutria. These species were selected because they are indicators of healthy, diverse wildlife habitat in Louisiana's coastal wetlands. In addition, extensive research has been done on the relative abundance of each of these species in each of the habitat types being evaluated. Because of the extremely large size of the study area (nearly 408,000 acres of marsh and swamp), it was decided to use published information, in lieu of extensive field sampling, to assign HSI's.

The habitat type supporting the greatest abundance of an evaluation element (species) was assigned the highest HSI. The remaining habitat types were assigned HSI's proportional to the abundance of an evaluation element in those habitat types compared to the abundance in the habitat type supporting the greatest abundance of that evaluation element.

The relative abundance data for nutria, muskrat, and migratory puddle ducks were taken from Palmisano (1973)and Chabreck (1978). For the American alligator, calculation of relative abundance was based on LDWF tag allotments for habitat types in the study area. The manner in which these relative abundance values were used to calculate HSI's is discussed below for each evaluation element.

Nutria - It was assumed that the average catch of nutria by trappers per 1,000 acres of each habitat type represents an index of nutria abundance by habitat type. To convert these relative abundance values to HSI'S, the habitat value with the highest nutria catch rate per 1,000 acres was assigned an HSI of 1.0, and the remaining habitat

Table A-5. Comparison of future without-project (FWOP) and future with-project (FWP) acreages of wooded swamp (WS), fresh-intermediate marsh (F/IM), brackish marsh (BM), saline marsh (SM), and total marsh in the Lake Pontchartrain/Chandeleur Sound area

Target Year		WS	F/IM	BM	SM	Total Marsh
		Habitat Type				
1978(baseline)		155,507	58,346	137,662	56,386	252,394
1990	FWOP	133,071	54,282	129,626	50,223	234,131
	FWP	133,071	54,282	129,626	50,223	234,131
2000	FWOP	116,868	51,111	123,288	45,604	220,003
	FWP	118,488	55,513	119,740	45,604	220,857
2010	FWOP	102,638	48,126	117,261	41,411	206,798
	FWP	105,681	52,646	114,496	41,411	208,553
2020	FWOP	90,140	45,315	111,528	37,603	194,446
	FWP	94,433	49,944	109,508	37,603	197,055
2030	FWOP	79,164	42,668	106,075	34,145	182,888
	FWP	84,555	47,400	104,763	34,145	186,308
2040	FWOP	69,525	40,177	100,889	31,005	172,071
	FWP	75,880	45,001	100,251	31,005	176,257
Annualized						
	FWOP	98,022	46,890	114,682	39,875	201,447
	FWP	101,527	51,029	112,689	39,875	203,593
Net Change		+3,505	+4,139	- 1,993	0	+ 2,146

types assigned HSI's calculated by the following equation:

Nutria HSI of particular habitat type =

$$\frac{\text{Mean nutria catch/1,000 acres of particular habitat type}}{\text{Mean nutria catch/1,000 acres of most productive habitat type}}$$

Table A-6 provides a display of mean nutria catch per 1,000 acres of each habitat type based on information compiled by Chabreck (1978), the calculated HSI by habitat type, and the adjusted HSI by habitat types. All habitat types were assumed to be approximately 20% below maximum nutria productivity; therefore, HSI's for each habitat type were multiplied by 0.8 to obtain an adjusted HSI.

Muskrat As was done for nutria, it was assumed that the average catch of muskrat per 1,000 acres of each habitat type represents an index of muskrat abundance by habitat type. The relative abundance values were converted to HSI's in the same manner as for the nutria relative abundance values in the preceding discussion.

Table A-7 provides a display of mean muskrat catch per 1,000 acres of each habitat type based on information compiled by Chabreck (1978), the calculated HSI by habitat type, and the adjusted HSI by habitat types. All habitat types were assumed to be approximately 20% below maximum muskrat productivity; therefore, HSI's for each habitat type were multiplied by 0.8 to obtain an adjusted HSI.

Table A-6. Mean nutria catch/1,000 acres of each habitat type, calculated nutria HSI values by habitat type, and adjusted HSI values by habitat type

Habitat Type	Mean Nutria Catch/1,000 acres	Calculated Nutria HSI value	Adjusted Nutria HSI value**
Fresh Marsh	512.7	1.00	0.80
Intermediate Marsh	284.9	0.56	0.45
Brackish Marsh	86.4	0.17	0.14
Saline Marsh	8.6*	0.02	0.02
Wooded Swamp	340.8	0.66	0.53

*Chabreck (1978) did not report a value for saline marsh; it was assumed that saline marsh is approximately 10% as productive as brackish marsh for nutria.

**All habitat types were assumed to be 20% below maximum value as nutria habitat; therefore, HSI values were multiplied by 0.8 to obtain adjusted HSI's.

Table A-7. Mean muskrat catch/1,000 acres of specific habitat types, calculated muskrat HSI values by habitat type, and adjusted HSI values by habitat type

Habitat Type	Mean Muskrat Catch/1,000 Acres	Calculated Muskrat HSI Value	Adjusted Muskrat HSI Value**
Fresh Marsh	78.5	0.81	0.65
Intermediate Marsh	97.5	1.00	0.80
Brackish Marsh	84.4	0.87	0.70
Saline Marsh	34.6	0.35	0.28
Wooded Swamp	42.3	0.43	0.34

*Chabreck (1978) did not report a value for saline marsh; it was estimated that saline marsh is 41% as productive as brackish marsh for muskrat based on a survey conducted by Palmisano (1973).

**All habitat types were assumed to be 20% below maximum value as muskrat habitat; therefore, HSI values were multiplied by 0.8 to obtain adjusted HSI's.

<u>Migratory Puddle Ducks</u> - A preference index was calculated for puddle ducks in marshes using data for southeastern Louisiana reported in Palmisano (1973). The calculation of that index is shown in Table A-8. The preference index for puddle ducks in wooded swamp was assumed to equal that of brackish marsh, i.e., 0.61 (Hugh Bateman, LDWF, personal communication dated July 21, 1983).

Table A-8. Calculation of preference index for migratory puddle ducks in marsh types of southeastern Louisiana

(a) Marsh type	(b) % of total Puddle ducks recorded	(c) % of habitat sampled	(d) Preference Index*
[illegible]	65.04	32.02	2.03
[illegible]	8.04	7.59	1.06
[illegible]	21.59	35.49	0.61
[illegible]	5.33	24.90	0.21

* [illegible] column (b) by column (c).

The preference index for each habitat type was converted to an HSI. To accomplish this, fresh marsh (highest preference index at 2.03) was given an HSI of 1.0and the HSI for other habitat types was calculated based on the following formula:

Migratory puddle duck HSI of specific habitat type =

$$\frac{\text{preference type index of specific habitat type}}{\text{2.03 (preference index for fresh marsh)}}$$

It was assumed that all habitat types are presently at 80% of full potential as migratory puddle duck habitat. Accordingly, migratory puddle duck HSI's were reduced by 20 percent.Table A-9 lists the calculated and adjusted migratory puddle duck HSI's for the habitat types.

Table A-9. Calculated and adjusted migratory puddle duck HSI's for various habitat types in southeastern Louisiana

Habitat Type	Calculated Puddle duck HSI	Adjusted Puddle Duck HSI*
Fresh Marsh	1.00	0.80
Intermediate Marsh	0.52	0.42
Brackish Marsh	0.30	0.24
Saline Marsh	0.10	0.08
Wooded Swamp	0.30	0.24

*Represents 80% of calculated HSI

Alligators - It was assumed that the LDWF average tag allotments for alligator harvest by habitat type for years 1981 and 1982 are a good index of alligator habitat quality. The average tag allotments for Ascension, Livingstron, Orleans, St. Bernard, St. Tammany, and Tangipahoa Parishes were utilized, and are shown in Table A-10.

Table A-10. Average 1981/1982 alligator tag allotments by habitat types for Ascension, Livingston, Orleans, St. Bernard, St. Tammany, and Tangipahoa Parishes

Habitat Type	Tag Allotment/Acres	Tag Allotment/1,000 Acres
Fresh Marsh	1/154	6.49
Intermediate Marsh	1/213	4.69
Brackish Marsh	1/444	2.25
Saline Marsh	0	0.00
Wooded Swamp	1/410	2.44

To calculate alligator HSI's for each habitat type, it was assumed that fresh marsh (highest tag allotment/1,000 acres) has an HSI of 1.00. Furthermore, it was assumed that the remaining habitat types have alligator HSI's based on the following formula:

$$\text{HSI of specific habitat type} = \frac{\text{tag allotment/1,000 acres of specific habitat type}}{\text{6.49 (Tag allotment for fresh marsh type)}}$$

It was also assumed that all habitat types are presently at 80% of their full potential as alligator habitat. This required downward adjustment of HSI's by 20 percent. Table A-11 displays calculated alligator HSI values for the various habitat types.

Table A-11. Calculated alligator HSI's by habitat types

Habitat Type	Alligator HSI	Adjusted Alligator HSI*
Fresh Marsh	1.00	0.80
Intermediate Marsh	0.72	0.58
Brackish Marsh	0.35	0.28
Saline Marsh	0.00	0.00
Wooded Swamp	0.38	0.30

*Calculated by multiplying HSI X 0.8; this was based on assumption that the habitat types are at 80% of full potential HSI for alligators.

The calculated HSI's were assumed to remain unchanged for both FWOP and FWP conditions. Multiplying the HSI of a given habitat type for each evaluation element by the target year acreage was accomplished to derive an estimate of the number of HU's for each evaluation element, by target year. These values were then annualized to obtain an estimate of the Average Annual HU's (AAHU's) under FWOP and FWP conditions, and the net gain or loss in AAHU's attributable to the proposed freshwater introduction.

A problem existed in that the fresh and intermediate marsh types were combined into a fresh-intermediate category in the acreage projections developed by FWS and NODCE personnel, while the HSI calculations were based on relative abundance data reported separately for the fresh and intermediate marsh types. This was solved by calculating the following weighted average HSI's for fresh-intermediate marsh: nutria, 0.65; muskrat, 0.72; puddle ducks, 0.64; and alligator, 0.70.

Table A-12 shows the net change in AAHU's in the area influenced by freshwater diversion. Nutria will experience the greatest habitat gains, with an increase of nearly 4,270 AAHU's. Puddle ducks, alligators, and muskrat will also be greatly benefitted, with increases of 3,970, 3,390, and 2,777 AAHU's, respectively.

Table A-12. Comparison of Average Annual Habitat Units (AAHU) under future without-project (FWOP) and future with-project (FWP) conditions in marshes and wooded swamp influenced by the proposed freshwater diversion.

Evaluation Elements	AAHU-FWP	AAHU-FWOP	Change in AAHU
Nutria	103,552	99,283	+4,269
Muskrat	161,307	158,530	+2,777
Puddle Ducks	87,739	83,770	+3,969
Alligator	97,731	94,341	+3,390

Literature Cited

Chabreck, R.H., 1978. Wildlife harvest in wetlands of the United States. Pages 618-631 in American Water Resources Association, national symposium on wetlands. Minneapolis, Minnesota.

Palmisano, A.W. 1973. Habitat preference of waterfowl and fur ani-animals in the northern Gulf Coast marshes. Pages 163-190 in R.H. Chabreck, ed. Proceedings of the coastal marsh and estuary management symposium. Louisiana State University Division of Continuing Education, Baton Rouge.

MISSISSIPPI AND LOUISIANA

ESTUARINE AREAS STUDY

APPENDIX B

MONETARY EVALUATION

OF

TENTATIVELY SELECTED PLAN

Table B-8. Fur catch and value by habitat type for coastal Louisiana

Species	Habitat Type: Fresh-Intermediate Marsh	Brackish Marsh	Saline Marsh	Wooded Swamp
Muskrat				
Average catch/acre[a]	0.0880[b]	0.0844	0.0169[c]	0.0273[d]
Value/pelt[e]	$5.43	$5.43	$5.43	$5.43
Value/acre	$0.4778	$0.4583	$0.0918	$0.1482
Nutria				
Average catch/acre	0.3988[b]	0.0864	insignificant	0.1995[d]
Value/pelt	$7.39	$7.39	-	$7.39
Value/acre	$2.9471	$0.6385	insignificant	$1.4743
Mink				
Average catch/acre	0.0015[b]	0.0011	insignificant	0.0216[d]
Value/pelt	$13.67	$13.67	-	$13.67
Value/acre	$ 0.0205	$ 0.0150	insignificant	$ 0.2953
Otter				
Average catch/acre	0.0005[b]	0.0002	insignificant	0.0005[d]
Value/pelt	$44.55	$44.55	-	$44.55
Value/acre	$ 0.0223	$ 0.0089	insignificant	$ 0.0223
Raccoon				
Average catch/acre	0.0093[f]	0.0078[g]	insignificant	0.0984[h]
Value/pelt	$11.46	$11.46	-	$11.46
Value/acre	$ 0.1066	$ 0.0894	insignificant	$ 1.1277
Total				
Average catch/acre	0.4979	0.1799	0.0169	0.3473
Gross value/acre	$ 3.5743	$ 1.2101	$0.0918	$3.0678
Net value/acre[i]	$ 2.6807	$ 0.9076	$0.0689	$2.3009

Continued

white) is expected to decline from 139,259 man-days in 1990 to about 79,040 man-days by 2040 under FWOP conditions. With the proposed freshwater diversion, small game hunting will decrease to 85,163 man-days by the year 2040. Waterfowl hunting will decline, under FWOP conditions, from 78,266 man-days in 1990 to 59,358 man-days in 2040. This activity will decrease to 61,570 man-days during the same period under FWP conditions. Hunting for other migratory birds (primarily rails and snipe) will decline from 34,575 man-days in 1990 to approximately 26,520 and 27,307 man-days by 2040 under FWOP and FWP conditions, respectively.

Commercial Wildlife - Increased fur animal and alligator harvests will result under FWP conditions when compared to FWOP conditions. Table B-8 displays average fur catch per acre by habitat type in coastal Louisiana, while Table B-9 shows the value of potential alligator harvest by habitat type in the Louisiana portion of the study area. Table B-10 displays the estimated value of commercial fur animal and alligator harvests in the Louisiana portion of the study area. As shown in Table B-10, the net value (price paid to the trapper minus cost of harvest) of commercial fur and alligator harvests will decline from $715,000 in 1990 to $457,000 by 2040 under FWOP conditions. With the proposed freshwater diversion, the net value of commercial fur animal and alligator harvests will decrease to $491,000 by the year 2040; fur animal harvest will comprise $388,000 of that total and the remainder ($103,000) represents alligator harvest value. The annualized increase in fur animal and alligator harvests attributable to the proposed freshwater introduction is $21,000.

Table B-11 summarizes the average annual value of project benefits to sport fishing and hunting, commercial fisheries, and commercial wildlife harvest. As shown in Table B-11, freshwater introduction will result in an increase in the average annual value by more than $6.7 million. Nearly 92.2 percent of this total is attributable to anticipated increases in oyster harvest, with the remainder attributable to sport fishing and hunting (6.6 percent), fur animals and alligator harvests (0.3 percent) and commercial finfish, shrimp and crab harvest (0.9 percent).

Table B-7. Projected sport hunting use (man-days) under future without-project (FWOP) and future with-project (FWP) conditions in the Louisiana portion of the study area

Target Year		Big game	Small game	Waterfowl	Other migratory birds
1990	FWOP	18,873	139,259	78,266	34,575
	FWP	18,873	139,259	78,266	34,575
2000	FWOP	16,675	124,105	74,031	32,787
	FWP	17,013	125,742	74,846	32,947
2010	FWOP	14,739	110,702	70,038	31,093
	FWP	15,265	113,673	71,234	31,422
2020	FWOP	13,032	98,841	66,271	29,486
	FWP	13,724	102,994	67,826	29,977
2030	FWOP	11,527	88,333	62,692	27,954
	FWP	12,367	93,539	64,608	28,606
2040	FWOP	10,203	79,040	59,358	26,520
	FWP	11,169	85,163	61,570	27,307
Annualized					
	FWOP	14,102	106,226	68,369	30,374
	FWP	14,678	109,632	69,686	30,779
Net Change		+ 576	+3,406	+1,317	+ 405

Table B-6. Populations of selected wildlife species expected to occur in wooded swamp, fresh/intermediate marsh and brackish marsh in the Louisiana portion of the study area under future without-project (FWOP) and future with-project (FWP) condition[a]

Target Year		Species			
		Deer	Rabbit	Mottled Duck	Wood Duck
1990	FWOP	2425	145,526	1319	1464
	FWP	2425	145,526	1319	1464
2000	FWOP	2140	133,205	1247	1286
	FWP	2181	134,897	1283	1303
2010	FWOP	1889	122,286	1181	1129
	FWP	1955	124,962	1221	1162
2020	FWOP	1668	112,339	1117	992
	FWP	1775	115,992	1162	1039
2030	FWOP	1474	103,346	1056	871
	FWP	1579	107,883	1107	930
2040	FWOP	1303	95,208	998	765
	FWP	1425	100,541	1053	835
Annualized					
	FWOP	1807	118,329	1155	1078
	FWP	1879	121,354	1191	1117
Net Change		+ 72	+ 3,025	+ 36	+39

a. Assumptions regarding calculation of populations are listed on Pages B-7, 8, & 10.

Squirrel Hunting - Man-day use figures for squirrel hunting were determined only for BLH and WS habitats. A population density of two squirrels per acre was used, this value coming from the LDWF parish surveys. A sustained annual harvest rate of 60% was assumed. A hunter success rate of 0.570 was used; this was derived from the LDWF 1977-78 small game survey for the District 8 area.

Quail Hunting - Man-day use figures for quail were determined only for BLH habitat. LDWF parish surveys for the project area indicated a population density of one quail per 100 acres of BLH habitat. A sustained annual harvest rate of 60% of the quail population was used in analysis. The LDWF 1977-78 small game survey revealed a hunter success rate of 0.620 for quail hunting in the project area vicinity.

Waterfowl Hunting - Man-day values for migratory waterfowl hunting in fresh and intermediate marsh habitat were based on records for public waterfowl hunting on Lacassine and Sabine National Wildlife Refuges (1978-79 hunting season). Man-day values of 0.454 per acre for fresh marsh and 0.521 man-day per acre for intermediate marsh were utilized. These two values were then averaged, as the acreages for fresh and intermediate marsh were combined in the projection of habitat conditions. Man-day values for brackish and saline marsh were taken from the U.S. Fish and Wildlife Service (1980). For BLH habitats, a population density of one bird per 10 acres, a sustained annual harvest rate of 40% and a hunter success rate of 0.400 were used. These figures were taken from the U.S. Fish and Wildlife Service (1980) and Kennedy (1977).

Rails and Snipe - Man-day values for these species were taken from U.S. Army Corps of Engineers (1974). The values for fresh and intermediate marsh types were averaged since the acreage figures for these two habitat types were combined.

The bulk of the acreage changes in the Louisiana portion of the study area association with the proposed freshwater diversion will occur in three habitat types, i.e., wooded swamp, fresh/intermediate marsh, and brackish marsh. Based on the acreage projections shown in Table B-1 and the data on wildlife population density displayed in Table B-4, estimates of populations of white-tailed deer, swamp rabbits, mottled ducks and wood ducks expected to occur in the areas identified above at key target years were developed for FWOP and FWP conditions (Table B-6). As shown in Table B-6, the proposed diversion of fresh water into the Louisiana portion of the study area will lead to an annualized (average annual) increase of 72 white-tailed deer; 3,025 swamp rabbits; and nearly 36 breeding pairs of mottled ducks and 39 breeding pairs of wood ducks.

Estimates of sport hunting use (man-days) calculated by the NODCE Recreation Planning Section are shown in Table B-7. As shown in Table B-7, big game (deer) hunting in the Louisiana portion of the study area will decline from 18,873 man-days in 1990 to 10,203 man-days by the year 2040 under FWOP conditions. Under FWP conditions, big game hunting effort is projected to decline to about 11,169 man-days by the year 2040. Small game hunting (primarily rabbits, squirrel, and bob-

Table B-5. Potential sport hunting effort (man-days) per acre for selected wildlife species in Louisiana Coastal Area[a]

	Potential Sport Hunting Effort (Man-days) Per Acre				
Species	Fresh/Int. Marsh	Brackish Marsh	Saline Marsh	Bottomland Hardwoods	Wooded Swamp
White-tailed deer	0.029	Neg.	Neg.	0.130	0.130
Squirrel	N/A	N/A	N/A	0.684	0.684
Swamp rabbit	0.164	0.131	0.033	0.164	0.164
Quail (Bobwhite)	N/A	N/A	N/A	0.004	Neg.
Waterfowl	0.488	0.383	0.018	0.016	0.053
Rails and snipe	0.188	0.188	0.250	Neg.	Neg.

a. Assumptions regarding calculation of sport hunting potential are provided on pages B-7,8, & 10.

Table B-4. Estimated population densities[a], by habitat type, of selected wildlife species in Louisiana Coastal Area

	Population Per Acre				
	Fresh/Int. Marsh	Brackish Marsh	Saline Marsh	Bottomland Hardwoods	Wooded Swamp
White-tailed deer	0.003	Neg.	Neg.	0.017	0.017
Squirrel	N/A	N/A	N/A	2.000	2.000
Swamp rabbit	0.500	0.400	0.100	0.500	0.500
Quail (Bobwhite)	N/A	N/A	N/A	0.010	Neg.
Mottled duck[b]	0.012	0.005	0.0004	N/A	N/A
Wood duck[c]	N/A	N/A	N/A	0.011	0.007

a. Population data obtained from Louisiana Department of Wildlife and Fisheries.

b. Mottled duck population estimates are for number of breeding pairs per acre, based on LDWF data, information reported in Bellrose (1976), and marsh acreage data in Chabreck (1972).

c. Wood duck population estimates are for number of breeding pairs per acre, based on information compiled by FWS and LDWF for the Atchafalaya Basin, Louisiana, study.

production of organic detritus, utilized as food by oysters, is expected to be substantially higher under FWP conditions.

The average adjusted oyster harvest in the study area is 8.0 million pounds annually, valued at $12.1 million, with a net value of nearly $3.6 million (gross exvessel value minus cost of harvest). This harvest level is assumed to continue over the period of analysis (1990-2040) under FWOP conditions. Under FWP conditions, potential annual harvest is expected to increase to 15.5 million pounds. NODCE Economics Branch predicted annual oyster fishery benefits (FWP net value minus FWOP net value) to range from $4.3 to $8.1 million, and to average about $6.5 million. This estimate is based on several scenarios which considered various levels of demand and profit.

EFFECTS ON WILDLIFE

Sport Hunting

An analysis of project impacts on sport hunting use was conducted by the NODCE Recreation Planning Section. Data were provided to NODCE by FWS on such items as population densities of selected wildlife species by habitat type (Table B-4) and potential hunting effort (man-days), by species, for the various habitat types in the study area (Table B-5). NODCE recreation specialists used these data and information on acreages of specific habitat types within and adjacent to the study area to conduct an analysis of sport hunting supply, demand, and needs for the FWOP and FWP conditions.

Assumptions Made in Calculation of Wildlife Populations and Sport Hunting Potential (Man-days) Per Acre

Deer Hunting - The value used for deer population density in fresh and intermediate marsh was one deer per 300 acres. This figure was provided by Bob Beter, Louisiana Deaprtment of Wildlife and Fisheries (LDWF) District Supervisor for District 8, New Orleans. The deer population density value used for bottomland hardwoods (BLH) and wooded swamp (WS) was one deer per 60 acres. This figure was obtained from surveys conducted by the LDWF for those parishes in the study area. Deer populations are considered negligible in brackish and saline marshes. The sustained annual harvest rate used for deer was 33%, a commonly accepted figure among wildlife biologists. The hunter success rat (i.e., average number of days of hunting required to kill one deer) used in this analysis was 23.7 for BLH and WS habitats, and 26.5 for fresh and intermediate marshes. These values were derived from the LDWF deer kill survey (1980-81 season).

Rabbit Hunting - Population density values used for rabbits were one animal per 2 acres in BLH, WS, and fresh and intermediate marshes; one per 2.5 acres in brackish marsh; and one per 10 acres in saline marsh. These values were taken from LDWF surveys of parishes in the study area. The sustained annual harvest rate used for rabbits was 60%, a commonly accepted value. A hunter success rate of 0.547 was used for all habitat types, reported in the LDWF state-wide 1977-78 small game survey, based on statistics for District 8.

pounds per acre. Therefore the annualized gain (i.e., reduction in loss) of 3,500 acres of swamp with the proposed freshwater diversion will result in an average increase of 231,000 pounds of estuarine-dependent commercial fisheries harvest per year having a net value of $18,940. The combined annualized estuarine-dependent commercial fisheries increases attributable to reduction in marsh and swamp losses with the proposed diversion are estimated at 716,000 pounds per year valued at nearly $59,000 annually (net value). It is emphasized that the above increases are actually reductions in the rate of decline in commercial harvest expected under FWOP conditions. Commercial harvest of all of the species discussed above will decline under both FWOP and FWP conditions; the rate will be smaller under FWP conditions.

An analysis of the impacts of the proposed freshwater introduction on commercial oyster harvest was performed by NODCE Economics Branch personnel, with considerable assistance in the development of the methodology being provided by FWS, Louisiana Department of Wildlife and Fisheries (LDWF), and NODCE biologists. Details regarding the methodology utilized are contained in Appendices D and F in the FR. For the projection of study area oyster harvest under FWOP conditions, it was assumed that the existing oyster harvest, presently in a state of decline, would remain stable based on projected hydrological conditions for this area. For FWP projections, it was assumed that potential oyster harvest would greatly increase and remain at that level as optimal salinity conditions for oyster production would be maintained over large areas of historically productive oyster bottoms in the western portion of Mississippi Sound and the Louisiana marshes east of the Mississippi River-Gulf Outlet. This assumption was based on a review of reports by LDWF and Gulf Coast Research Laboratory (GCRL) biologists (Pollard 1973, Dugas 1977, Chatry et al. 1983, Gunter 1975, and Demoran 1966) and consultation with LDWF, GCRL, and Mississippi Bureau of Marine Resources biologists.

The proposed freshwater diversion would result in a spring freshening over large areas of historically productive oyster bottoms which would control many of the oyster predators as well as many of the fouling organisms which inhibit oyster spat sets. This plan was recommended by the ad hoc interagency group established for this study. Increased salinities are primarily responsible for the long-term decline in oyster production as many of the oyster predators and fouling organisms require higher salinities for survival. Control of the southern oyster drill is the primary reason that the State of Louisiana has constructed and subsequently enlarged a freshwater diversion structure at Bayou Lamoque in southern Plaquemines Parish, and was a major justification for four unconstructed Federally-authorized diversion structures on the Mississippi River below New Orleans. The proposed freshwater diversion will also increase nutrient levels in the affected oyster growing areas, with an anticipated increase in populations of plankton consumed by oysters. The far greater nutrient content of Mississippi River water compared to that of adjacent estuaries unaffected by river discharge has been reported by Ho and Barrett (1975). Increased nutrient input into affected marsh areas will reduce marsh loss and increase plant growth. As a result, the

Table B-3. Combined harvest[a] of major estuarine-dependent commercial fishes, shrimp, and crabs attributable to the study area (data based on 1963-1978 average annual reported commercial landings[b])

Species	Harvest (millions of pounds)
Menhaden	51.85
Shrimp	27.94
Blue Crab	2.68
Croaker	1.83
Red Drum	0.14
Seatrout	0.47
Spot	0.02
Total	
Harvest	84.93
Marsh Acreage[c]	0.320
Harvest (lbs)/Marsh Acre[d]	226.38
Wooded Swamp Acreage[c]	0.189
Harvest (lbs)/wooded swamp acre[d]	66.05

a. Harvest refers to total inshore and offshore harvest attributable to the study area.

b. Source: National Marine Fisheries Service landing records compiled and adjusted by New Orleans District, Corps of Engineers.

c. From Wicker (1980), in millions of acres.

d. Based on methodology developed by U.S. Army Corps of Engineers (1977).

sumers of Lake Pontchartrain. The contribution of vascular plant detritus to estuarine fisheries productivity was also documented by Odum et al. (1973). Marshes and associated shallow ponds and tidal creeks are also important as habitat for many estuarine-dependent species. Recent studies conducted within the upper Barataria Basin have substantiated the value of shallow marsh areas as nursery habitat for numerous estuarine-dependent species (Chambers 1980, Daud 1979, Rogers 1979, and Simoneaux 1979). Shallow marsh areas are also important as nursery grounds for brown shrimp and white shrimp in coastal Louisiana, according to studies conducted by biologists of the Louisiana Department of Wildlife and Fisheries (White and Boudreaux 1977). A three-year investigation of a low-salinity marsh area in the Galveston Bay System of southeastern Texas revealed that shallow marsh waters were prime habitat for immature shrimp (brown and white), gulf menhaden, Atlantic croaker, sand seatrout, and southern flounder (Conner and Truesdale 1973).

There is growing evidence that the acreage of marsh is the most important factor influencing the production of estuarine-dependent species of sport and commercial importance in the Gulf area. Turner (1979) reported that the Louisiana commercial inshore shrimp catch is directly proportional to the area of intertidal wetlands, and that the area of estuarine water does not seem to be directly associated with average shrimp yields. Lindall et al.(1972) presented evidence that shrimp and menhaden are being harvested at or near maximum sustainable yield. An analysis by Cavit (1979) of the dependence of menhaden catch on wetlands in coastal Louisiana suggested that menhaden yields are greatest in those hydrologic units having the highest ratio of marsh to open water. Harris (1973) has stated his opinion that total estuarine-dependent commercial fisheries production in coastal Louisiana has peaked and will decline in proportion to the acreage of marsh lost. Based on these considerations, it was assumed that the magnitude of future declines in wetland acreages (Table B-1) will determine future commercial estuarine-dependent finfish and shellfish yields.

Table B-3 displays the combined average adjusted harvest of major estuarine-dependent commercial fishes, shrimp, and crabs attributable to the study area. As shown in that table, an average annual estuarine-dependent commercial fisheries harvest of nearly 85 million pounds was recorded during 1963-1978. According to the Corps of Engineers (1977) approximately 85.3 percent (72.4 million pounds) of that production can be assigned to the 320,000 acres of marsh in the study area, or approximately 226 pounds per acre of marsh. The proposed diversion, when compared to FWOP conditions, would result in an average annual reduction in marsh loss amounting to 2,150 acres and a 485,000-pound relative increase in commercial fisheries harvest valued at $203,700 annually or $39,770 after the cost of harvest is subtracted; the cost of harvest was derived from U.S. Army Corps of Engineers (1982). The 188,700 acres of wooded swamp in the study area is responsible for an estimated 14.7 percent (12.5 million pounds) of the total estuarine-dependent commercial fisheries production in that area (U.S. Army Corps of Engineers, 1977) and yielded an average of 66

Table B-2. Projected magnitude and value of sport fishing use under future without-project (FWOP) and future with-project (FWP) conditions in the study area

Target Year		Use (Man-days)	Value per man-day ($)	Total Value($)
1978	FWOP	1,822,800	4.20	7,655,760
	FWP	1,822,800	4.20	7,655,760
1990	FWOP	1,822,800	4.20	7,655,760
	FWP	1,931,100	4.20	8,110,620
2000	FWOP	1,822,800	4.20	7,655,760
	FWP	1,931,100	4.20	8,110,620
2010	FWOP	1,822,800	4.20	7,655,760
	FWP	1,931,100	4.20	8,110,620
2020	FWOP	1,822,800	4.20	7,655,760
	FWP	1,931,100	4.20	8,110,620
2030	FWOP	1,822,800	4.20	7,655,760
	FWP	1,931,100	4.20	8,110,620
2040	FWOP	1,822,800	4.20	7,655,760
	FWP	1,931,100	4.20	8,110,620
Average Annual				
	FWOP	1,822,800	4.20	7,655,760
	FWP	1,920,620	4.20	8,066,600
Net Change		+ 97,820	0	+ 410,840

Table B-1. Comparison of future without-project (FWOP) and future with-project (FWP) acreages of wooded swamp (WS), fresh-intermediate marsh (F/IM), brackish marsh (BM), saline marsh (SM), and total marsh in the Lake Pontchartrain/Chandeleur Sound area

		Habitat Type				
Target Year		WS	F/IM	BM	SM	Total Marsh
1978 (baseline)		155,507	58,346	137,662	56,386	252,394
1990	FWOP	133,071	54,282	129,626	50,223	234,131
	FWP	133,071	54,282	129,626	50,223	234,131
2000	FWOP	116,868	51,111	123,288	45,604	220,003
	FWP	118,488	55,513	119,740	45,604	220,857
2010	FWOP	102,638	48,126	117,261	41,411	206,798
	FWP	105,681	52,646	114,496	41,411	208,553
2020	FWOP	90,140	45,315	111,528	37,603	194,446
	FWP	94,433	49,944	109,508	37,603	197,055
2030	FWOP	79,164	42,668	106,075	34,145	182,888
	FWP	84,555	47,400	104,763	34,145	186,308
2040	FWOP	69,525	40,177	100,889	31,005	172,071
	FWP	75,880	45,001	100,251	31,005	176,257
Annualized						
	FWOP	98,022	46,890	114,682	39,875	201,447
	FWP	101,527	51,029	112,689	39,875	203,593
Net Change		+ 3,505	+4,139	- 1,993	0	+ 2,146

INTRODUCTION

This appendix summarizes the anticipated monetary effects of the tentatively recommended plan on sport and commercial fishing, sport hunting, and commercial fur and alligator harvest. These estimates are based primarily on differences in wetland acreages and salinity regimes in the study area expected to occur under future without-project (FWOP) versus future with-project (FWP) conditions (Table B-1).

EFFECTS ON FISHERIES

Sport

Project impacts on sport fishing were estimated by the Recreation Planning Section of the New Orleans District Corps of Engineers (NODCE), with some assistance from the Fish and Wildlife Service (FWS). The NODCE analysis combined freshwater fishing and saltwater fishing into a single category. A detailed explanation of the methodology used in that analysis is contained in Appendix G accompanying the feasibility report (FR) for this study. This analysis was based on the premise that sportfishing opportunity (supply), in terms of total man-days, is limited by access to the fishery. As shown in Table B-2, NODCE recreation specialists assumed that the total sportfishing effort will remain constant at 1,822,800 man-days peryear over the [illegible] (1990-2040) under FWOP conditions. This assumption was made [illegible] access facilities (primarily the number of boat launching [illegible] determined by NODCE recreation specialists to be [illegible] meet present demand and were not projected to increase substantially during the project life. Under FWP conditions total sportfishing effort will increase as one project feature includes development of additional access facilities. As shown in Table B-2, the average annual monetary value of sport fishing is estimated at nearly $7,655,760 under FWOP conditions and approximately $8,066,600 under FWP conditions. Therefore, a net annualized increase of almost $410,840 [illegible] the value of sportfishing has been attributed to the tentatively selected plan.

Commercial

Freshwater- Of the total commercial fishery landings attributable to the study area, less than one percent is comprised of freshwater species; the remainder is made up of estuarine-dependent species. Therefore, no attempt was made to quantify project effects on freshwater commercial fisheries. A discussion of the potential qualitative impacts of the project on commercial freshwater fisheries is found in the main report.

Estuarine-Dependent - The importance of marshes to estuarine-dependent fisheries in coastal Louisiana cannot be over-emphasized. These marshes produce vast amounts of organic detritus which are transported into adjacent estuarine waters. The importance of plant detritus in estuarine food webs is well documented. Darnell (1961) concluded that detritus of vegetable original seemed to be the single most important food material ingested by the fish and invertebrate con-

Table B-8. Continued

a. Average catch per acre, unless otherwise noted, from Palmisano (1973).

b. Represents mean of fresh and intermediate marsh average harvest/acre reported by Palmisano (1973).

c. Calculated as 25 percent of brackish marsh average harvest/acre reported by Palmisano (1973).

d. Calculated as a percentage of fresh marsh average harvest/acre reported by Palmisano (1973), based on a comparison by Nichols and Chabreck (1973) of the harvest per acre in wooded swamp and fresh marsh habitats.

e. Based on 1976-81 running average of prices received by the trapper, expressed in 1981 dollars using the Consumer Price Index for hides, skins, leather and related products. Base price data compiled by Louisiana Department of Wildlife and Fisheries.

f. Represents one half of the combined maximum production for fresh and intermediate marsh types reported by Palmisano (1973).

g. Represents one half the maximum value for brackish marsh reported by Palmisano (1973).

h. Based on harvest projected by Nichols and Chabreck (1973).

i. Cost of harvest equals 25 percent of gross value; net value equals gross value minus cost of harvest.

Table B-9. Value of potential alligator harvest by habitat type in the Louisiana portion of the study area[a]

	Habitat Type			
	Fresh-Intermediate Marsh	Brackish Marsh	Saline Marsh	Wooded Swamp
Mean harvest (hides/acre)	0.0057	0.0023	negligible	0.0024
Mean value/ hide[b]	$133.00	$133.00	N/A	$133.00
Mean value of meat/animal[c]	$ 71.40	$ 71.40	N/A	$ 71.40
Mean total value/animal	$204.40	$204.00	N/A	$204.40
Total value (gross)/acre	$ 1.17	$ 0.47	negligible	$ 0.49
Net value (gross value less cost of harvest)/ acre[d]	$ 0.88	$ 0.35	negligible	$ 0.37

a. Data on hide value, mean hide length, mean weight, and harvest provided by Ted Joanen and David Richard, Louisiana Department of Wildlife and Fisheries, Grand Cheniere, Louisiana.

b. Based on mean length/hide of 7 feet and mean 1981-1982 hide price of $16.50 per linear foot.

c. Based on mean dressed weight/animal of 47.6 pounds and estimated 1982 mean price of $1.50 per pound.

d. Based on cost of harvest equal to 25 percent of total gross value.

Table B-10. Net value[a] of commercial wildlife harvest under future without-project (FWOP) and future with-project (FWP) conditions in the Louisiana portion of the study area

(thousands of dollars)

Target Year		Fur animals	Alligators	Total
1990	FWOP	573	142	715
	FWP	573	142	715
2000	FWOP	521	131	652
	FWP	533	135	668
2010	FWOP	474	121	595
	FWP	491	126	617
2020	FWOP	433	112	545
	FWP	453	117	570
2030	FWOP	395	104	499
	FWP	419	110	529
2040	FWOP	361	96	457
	FWP	388	103	491
Average Annual net returns				
	FWOP	458	118	576
	FWP	475	122	597
Increase		17	4	21

a. Net value represents gross value minus cost of harvest; cost of harvest is 25% of gross price paid to trapper.

Table B-11. Summary of average annual increases in net monetary values for sport fishing and hunting, commercial fisheries, and commercial fur animal and alligator harvests in the study area

	Average annual increase (thousands of dollars)
Sport fishing and hunting[a]	455
Commercial fisheries	
oysters[a]	6,540
other	59
total	6,599
Commercial fur animal and alligator harvest[b]	21
Total	7,075

a. Represents average annual equivalent value, calculated by New Orleans District Corps of Engineers Economics Branch at 8 1/8% discount rate.

b. Represents net harvest value from Louisiana portion of study area only.

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OPTIMUM SALINITY REGIME FOR OYSTER PRODUCTION ON LOUISIANA'S STATE SEED GROUNDS

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Exhibit A

ABSTRACT

Salinity, spatfall, and seed oyster production data from three stations on Louisiana's prime seed grounds were collected from 1971-1981. Examination of the relationships between each of the variables revealed that salinity during the year in which spatfall occurred was closely related to the production of seed oysters in the ensuing year. The optimum annual salinity regime was derived from all of the year/station regimes which were associated with good seed production (>20 oysters/m^2). The relationship between the optimum regime and seed production was expressed with the regression equation: Seed production =

$$-43.89 \pm 2144.5\ (\Sigma \text{ monthly deviations from the optimum regime }^{-1}).$$

The critical months within the optimum annual regime appear to be May through September. Optimum May salinities are from 6-8 ppt. Salinities should average 13 ppt in June and July and not increase to greater than 15 ppt until late August. September salinities should not average more than 20 ppt.

INTRODUCTION

The Louisiana oyster *Crassostrea virginica* (Gmelin) industry relies heavily upon seed oysters produced on state-controlled seed grounds. Historically, the most productive of these grounds has been an area east of the Mississippi River of approximately 200,000 acres (Mackin and Hopkins 1961). Man-induced perturbations, such as levee construction and channelization, coupled with the natural processes of deltaic decline have resulted in steadily increasing salinities over the entire grounds (Gagliano, Meyer-Arendt and Wicker 1981). Coincident with increasing salinities has been a decrease in the size of the area producing seed oysters. Several researchers have reported that the decreased area is in fact a result of the increased salinities (Gunter 1953, Pollard 1973, Dugas 1977).

In an attempt to reverse the landward salinity intrusion and thereby re-establish formerly productive reefs, a number of structures designed to divert Mississippi River water to the area of the seed grounds have been constructed or are now being planned. The most efficient structure envisioned to date would theoretically shift the 15 ppt mean isohaline to pre-1950 locations for nine out of every ten years (U.S. Army Corps of Engineers, New Orleans District 1970). Maintenance of this line is expected to increase seed oyster production dramatically.

Fifteen ppt was chosen (Theodore B. Ford, Louisiana Department of Wildlife and Fisheries, personal communication) primarily due to the inability of the oyster drill, *Thais haemastoma canaliculata* (Gray), to flourish in waters less than 15 ppt (Butler 1954, Chapman 1959). However, Gunter (1955) stated there are several organisms, in addition to the oyster drill, whose abundance is salinity dependent and which limit

oyster production. These include predators such as portunid and xanthid crabs, predaceous polychaetes, boring gastropods, and fouling organisms which inhibit oyster set such as boring and encrusting sponges, barnacles, bryozoans and algae. If these organisms, along with other salinity dependent factors such as gametogenesis (Butler 1949) and larval survival (Davis 1958), play an important role in seed oyster production, then maintenance of the 15 ppt mean isohaline may not be the most judicious use of the diversion potential.

Determination of the optimum salinity or salinity regime for seed oyster production in Louisiana could conceivably be accomplished by incorporating each of the variables governing production and their individual responses to salinity. A more direct approach, however, would be to examine the relationship between salinity and seed oyster production for a number of years in which production ranged from good to bad. The purpose of this report is to determine the optimum annual salinity regime, using historical data, for the production of seed oysters on Louisiana's seed grounds.

AREA DESCRIPTION AND HYDROLOGY

The state's prime seed grounds lie in the deltaic plain of the Mississippi River in southeastern Louisiana (Fig. 1). The area is bordered on the west and south by the Mississippi River, on the north by Bayou Terre aux Bouefs (an abandoned distributary of the Mississippi), and on the east by Breton Sound.

Since the virtual completion of the Mississippi's levee system from New Orleans to Baptiste Collette Bayou, alluviation in this area from overbank flooding has been minimal. As a result, the area is presently in a

state of decline characterized by subsidence and erosion with land masses slowly being replaced by shallow bay systems (Gagliano et al. 1981).

Salinities in the area generally increase from the interior marshes to the open bays at times when local rainfall dominates the freshwater input. However, when the Mississippi or Pearl rivers are at a high stage, freshwater or freshened seawater often enters the area from the open waters of Breton Sound. The Bonnet Carre Spillway, a flood control structure of the Mississippi which drains into Lake Pontchartrain, has the potential to greatly reduce salinities on the seed grounds but the structure has been used only seven times since its construction in 1935. There are also three diversion structures located at Bellair, Bohemia and Bayou Lamoque which supply river water to the area. These have a relatively small and localized effect on seed ground salinities due to their position and their limited capacities. A proposed diversion structure at Caernarvon will have a much larger dilution capability due to the vast expanse of marsh acting as a freshwater reservoir between the structure and the seed grounds (U.S. Army Corps of Engineers, New Orleans District 1982).

METHODS

Salinity, spatfall and seed oyster production data were collected over an approximate 10-year period from April 1971 to September 1981 from three areas within Louisiana's prime seed grounds. We have designated the areas Black Bay, Bay Gardene and California Bay (Fig. 2).

Salinity was recorded weekly at a permanent station within each of the three areas. Spatfall was measured using 10 x 10 cm collecting plates modified from Butler (1955). The plates were deployed weekly in each area adjacent to the salinity stations. Upon retrieval, spat were counted and

mean spat/cm^2 was calculated. We [illegible] intensities on the collecting plates were a reliable index of the available set.

Seed oyster production was determined by the [illegible] square meter method using SCUBA (May 1972). An average of [illegible] replicate samples was taken in June or July in each of the three areas from 1974-1981. In general, the same reefs were sampled each year even though the precise sampling sites may have been different. The oysters were separated into size groups of 1-25 mm, 26-50 mm, 51-75 mm, and >75 mm. Oysters 26-75 mm in height were designated as seed oysters. According to St. Amant (1958), most Louisiana oysters in this size range are from 7-14 months old. Therefore, seed oysters sampled in June-July probably set from April to October during the preceding year. An average of 20 seed oysters/m^2 on the reefs of the public ground is required to satisfy the minimum requirements of the fishery. Therefore, we identified seed production data above and below 20 seed oysters/m^2 as "good" or "poor" production, respectively.

RESULTS AND DISCUSSION

A wide range of mean annual salinities (10.7 to 23.0 ppt) and seed oyster production (0.7 to 224.3 oys./m^2) was observed during the period studied. In order to construct the optimum salinity regime for seed production we sought to identify the relationships between salinity and set, set and seed production, and salinity and seed production.

Set vs. Salinity

Over 85% of the setting which occurred at the three stations from 1971-1980 took place in June through September. For this reason we chose these four months, hereafter referred to as "summer", in our comparison

of set and salinity. The mean summer set per spat collector in 2 ppt intervals is shown in Figure 3. Approximately 400 set/salinity values are represented.

Virtually no setting took place when mean summer salinity was less than 10 ppt (Table 1). Setting intensities were minimal (<0.1 spat/cm^2) from 10-12 ppt. At summer salinities of 12-16 ppt, setting increased to approximately 1.0 spat/cm^2. From 16-22 ppt setting intensity was consistently high with a peak occurring between 20 and 22 ppt. Setting intensity decreased substantially above 22 ppt but remained higher than the intensities observed at less than 16 ppt.

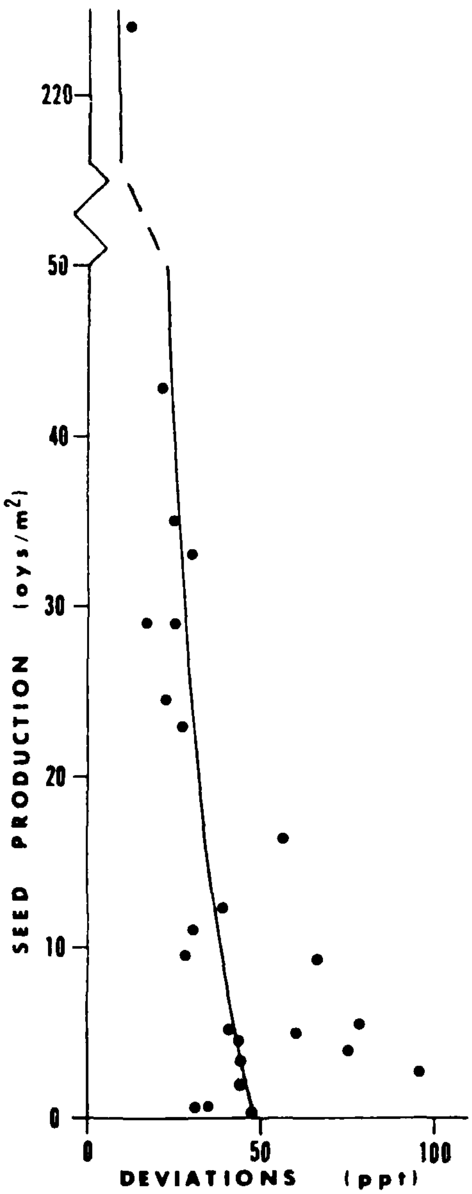
May and Bland (1970) also found greater setting intensities associated with higher salinities. Possible explanations of this relationship include suppressed gametogenesis (Butler 1949, Davis and Calabrese 1964) and reduced larval survival (Davis 1958, Calabrese and Davis 1970) at lower salinities.

Production vs. Set

In comparing seed production and set we assumed a lag of approximately one year between set and seed oysters. The years with heavy sets were followed by years of poor seed production. Likewise, the lighter sets often resulted in better production (Fig. 4, Table 1). An inverse relationship between production and set was also noted by Webster and Shaw (1968) on the eastern shore of the Chesapeake Bay.

An exception to this relationship was seen for the three lightest setting intensities. In these cases mean summer salinities of less than 12 ppt apparently reduced setting (<0.1 spat/cm^2) to the extent that production was limited. These values were obscured in Figure 4 due to

Figure 8



220
50
40
30
20
10
0
SEED PRODUCTION (oys/m²)
0
50
100
DEVIATIONS (ppt)

Figure 7

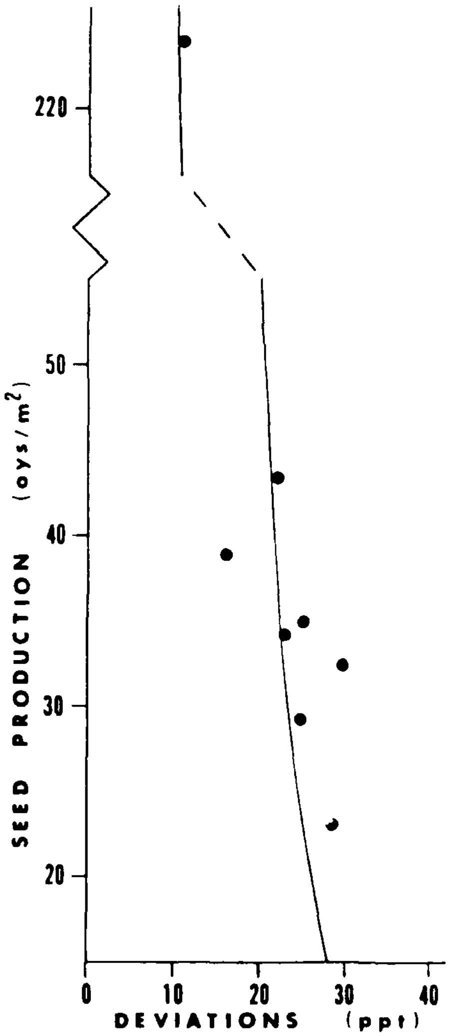

220
50
40
30
20
SEED PRODUCTION (oys/m2)
0
10
20
30
40
DEVIATIONS (ppt)

Figure 6

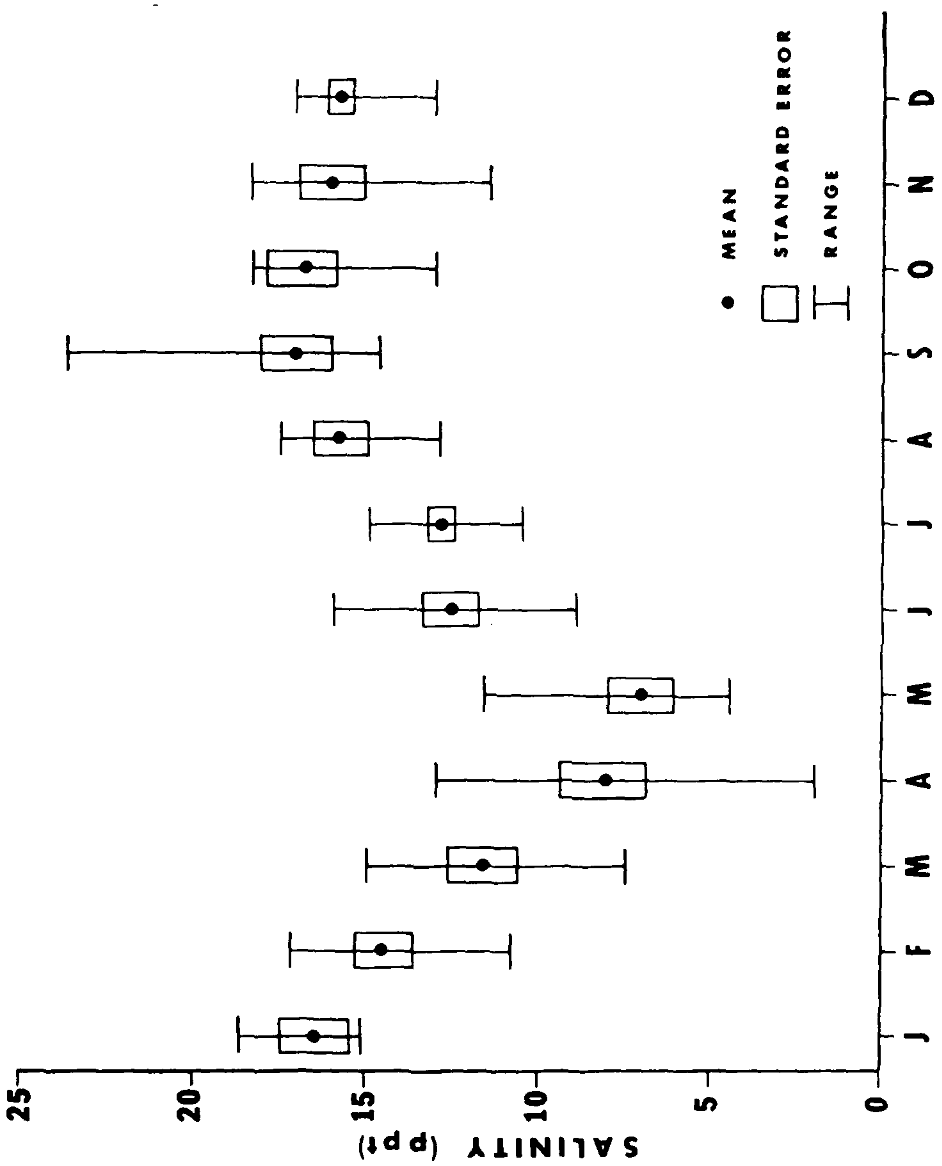
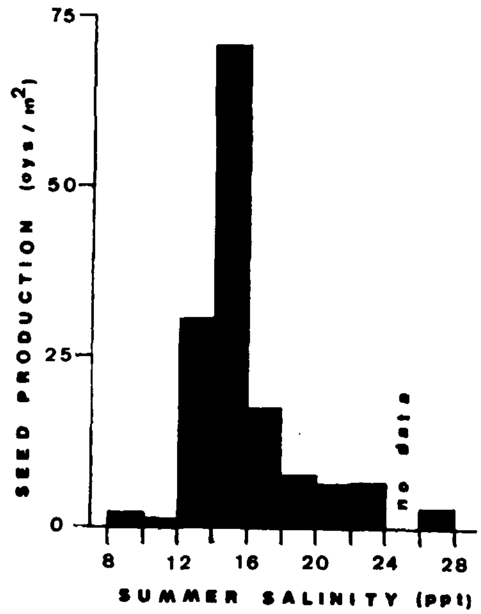

MEAN
STANDARD ERROR
RANGE
SALINITY (ppt)
25
20
15
10
5
0
MONTH
J
F
M
A
M
J
J
A
S
O
N
D

Figure 5



75
50
25
0
SEED PRODUCTION (oys / m^2)
no data
8
12
16
20
24
28
SUMMER SALINITY (ppt)

Figure 4

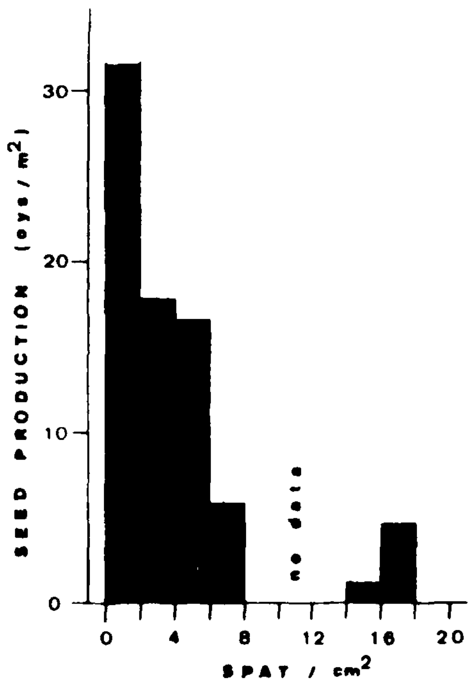


Figure 3

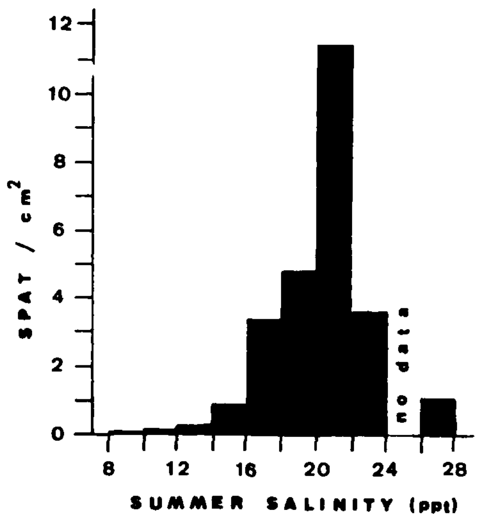

12
10
8
6
4
2
0
SPAT / cm^2
no data
8
12
16
20
24
28
SUMMER SALINITY (ppt)

Figure 2

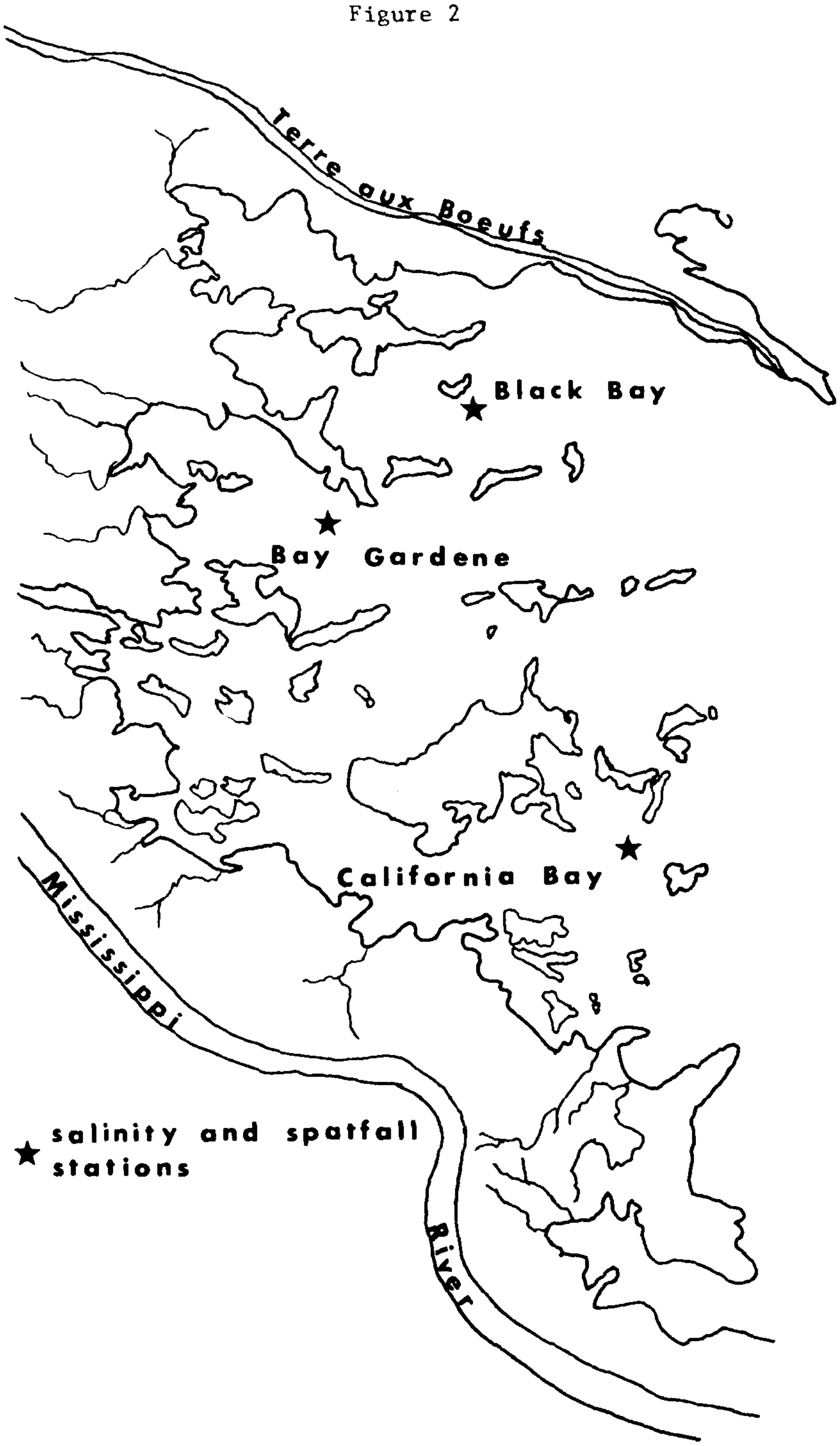

Terre aux Boeufs
Black Bay
Bay Gardene
California Bay
Mississippi River
salinity and spatfall stations

Figure 1


Pearl River
Lake
Pontchartrain
Bonnet Carre
Caernarvon
Terre aux Boeufs
Mississippi River
Bellair
Bohemia
Bayou
Lamoque
Breton
Sound
prime
seed ground

LIST OF FIGURES

Table 1

Salinity, set, and seed production values for each area, 1971-1981.

Year	Mean Summer* Salinity (ppt)	Mean Summer* Set (spat/cm^2)	Seed Production (oysters/m^2)
		Black Bay	
1971	18.4	4.3	---
72	18.7	9.3	---
73	15.1	2.4	---
74	19.4	1.6	43.3
75	16.7	7.0	5.2
76	20.2	18.9	9.7
77	23.3	3.3	4.6
78	11.3	0.0	4.0
79	14.4	0.4	0.8
80	21.1	5.6	224.3
81	---	---	16.4
		Bay Gardene	
1971	16.5	1.4	---
72	18.5	4.9	---
73	12.2	0.2	---
74	16.7	0.4	39.0
75	14.8	0.5	11.2
76	17.4	5.2	29.2
77	23.1	3.3	32.4
78	9.1	0.0	9.2
79	12.5	0.3	2.3
80	18.8	5.0	23.1
81	---	---	12.3
		California Bay	
1971	21.1	8.2	---
72	19.5	5.8	---
73	14.6	0.5	---
74	18.3	2.0	35.0
75	21.5	7.0	4.9
76	20.5	15.7	1.9
77	27.1	1.2	1.1
78	11.7	0.1	2.8
79	14.6	0.4	0.7
80	24.1	5.8	24.4
81	---	---	5.4

*Summer = June, July, August and September

in a given year could be predicted using the overall regression equation relating seed production to deviations from the optimum regime. Also, cultch planting operations could be planned to take full advantage of favorable salinities. Perhaps the greatest potential application for the optimum regime, however, lies in managing the proposed freshwater diversions for maximum seed oyster production. The timing and magnitude of the diversions should be controlled to establish the optimum regime over those areas of maximum reef density on the state seed grounds.

salinity regimes. Differences between the optimum regime and the high and low salinity composites are most pronounced for May through September, indicating that summer salinities may be particularly important in the production of seed oysters. This is further supported by Ulanowicz, Caplins and Dunnington (1980) in their use of spawning season salinities for the prediction of spat densities, and by Gunter (1955) who found that salinity conditions during the summer months determine the extent of predator induced mortalities.

CONCLUSIONS

Salinity in the setting year is perhaps the prime determining factor for the production of seed oysters on the state seed grounds Both high and low extreme salinities are associated with poor seed production. While poor production at the low salinities can be related to insufficient setting, the mechanisms by which high salinities limit production are speculative in the absence of more specific mortality data. We believe, however, that high salinities allow for the proliferation of numerous organisms which adversely affect setting and recently set oysters. The largest differences between the optimum regime and the high salinity regimes were seen in May through September, the time in which virtually all setting occurs.

Since the optimum salinity regime was based on recorded successes in seed production, the regime is sensitive to the direct and indirect relationships between salinity and seed production. In effect, the regime represents the salinity profile for maximum observed seed production. Knowledge of the relationship of salinity to production has several possible applications. Success or failure of seed production

remarkable similarity among the eight year/station regimes which were followed in the ensuing year by good seed oyster production. Consequently, we theorized that a composite or mean regime of these eight would approach the optimum for seed production (Fig. 6). To test this theory we took the sum of the monthly salinity deviations in ppt from the composite, for each of the eight regimes, and plotted these deviations versus the corresponding seed production. As expected, seed production decreased as the deviation from the composite increased (Fig. 7). The equation expressing this relationship is:

$$\text{Seed production} = -103.827 + 3299.23\ (\Sigma \text{ monthly deviations}^{-1})$$
$$\text{with } R^2 = 0.81;\ F = 25.9,\ p < 0.01;\ n = 8.$$

When the 16 year/station regimes followed by poor seed production are incorporated into the plot of the 8 year/station regimes followed by good production, the same general relationship holds true (Fig. 8). Seed production decreased as the sum of the monthly deviations from the composite regime increased. The equation expressing the relationship for all 24 year/station regimes is:

$$\text{Seed production} = -43.89 + 2144.5\ (\Sigma \text{ monthly deviations}^{-1})$$
$$\text{with } R^2 = 0.70;\ F = 51.3;\ p < 0.001;\ n = 24.$$

It appears from these two relationships that the composite drawn from the eight year/station regimes followed by good seed production is a sound estimate of the optimum salinity regime for the production of seed oysters. Hereafter, it will be referred to as the optimum regime.

Of the 16 year/station regimes followed by poor seed production, 13 deviated from the optimum primarily due to high salinities and 3 due to low salinities. Figure 9 shows a composite of the 13 high salinity regimes, the optimum salinity regime, and a composite of the 3 low

their inclusion in the 0-2 spat/cm^2 interval.

Good seed production resulted from setting intensities as low as 0.2 spat/cm^2. Therefore, sets of 0.2 spat/cm^2 or greater were apparently sufficient for good seed production. If production was poor despite sufficient setting, as was more often the case, then other limiting factor(s) were responsible.

Production vs. Salinity

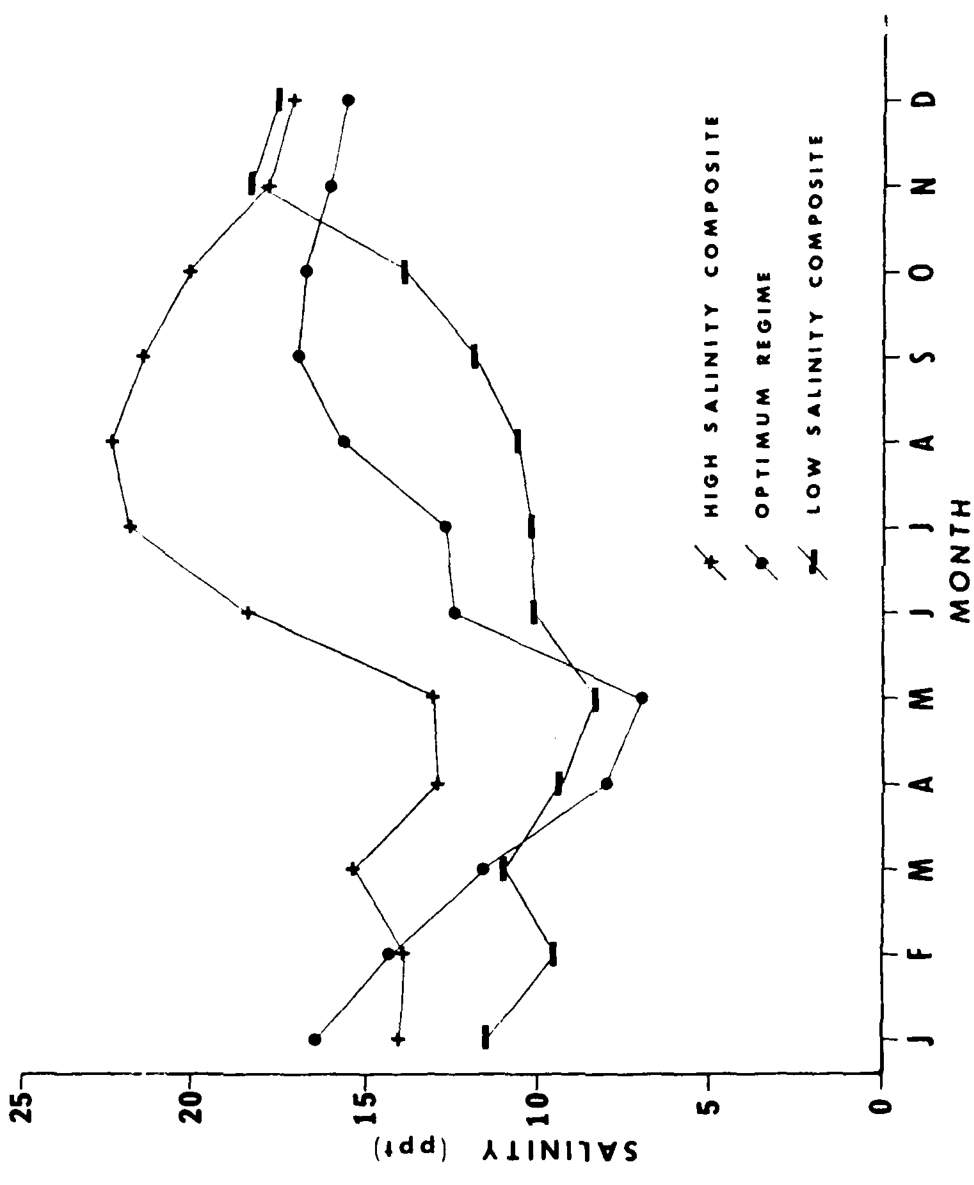
The relationship between mean summer salinities at setting and seed production in the ensuing year for all three stations (1973-81) is shown in Figure 5. A fairly narrow range of salinities (12.2-17.4 ppt) was associated with good seed production (Table 1). On either side of the range, production was severely restricted. Poor production for the low salinities (<12.2 ppt) was associated with minimal set. Since setting was sufficient at the high salinities (>17.4 ppt), it appears that the resultant poor production was due to other salinity dependent factors.

Gunter (1955) offers possible identification of these factors. He found a direct relationship between high salinities and high oyster mortalities. He attributed these mortalities to the increased abundance of oyster predators associated with the high salinities.

Optimum Regime

In the preceding discussions we have used mean summer salinities in the comparisons with set and production. Mean values are helpful in demonstrating general associations but from a practical standpoint (i.e., freshwater diversion) a monthly salinity regime for the entire year is needed. Towards this end, we plotted salinity regimes by month for each year at each station - a total of 24 year/station regimes. There was a

Figure 9



SALINITY (ppt)
25
20
15
10
5
0
J
F
M
A
M
J
J
A
S
O
N
D
MONTH
HIGH SALINITY COMPOSITE
OPTIMUM REGIME
LOW SALINITY COMPOSITE

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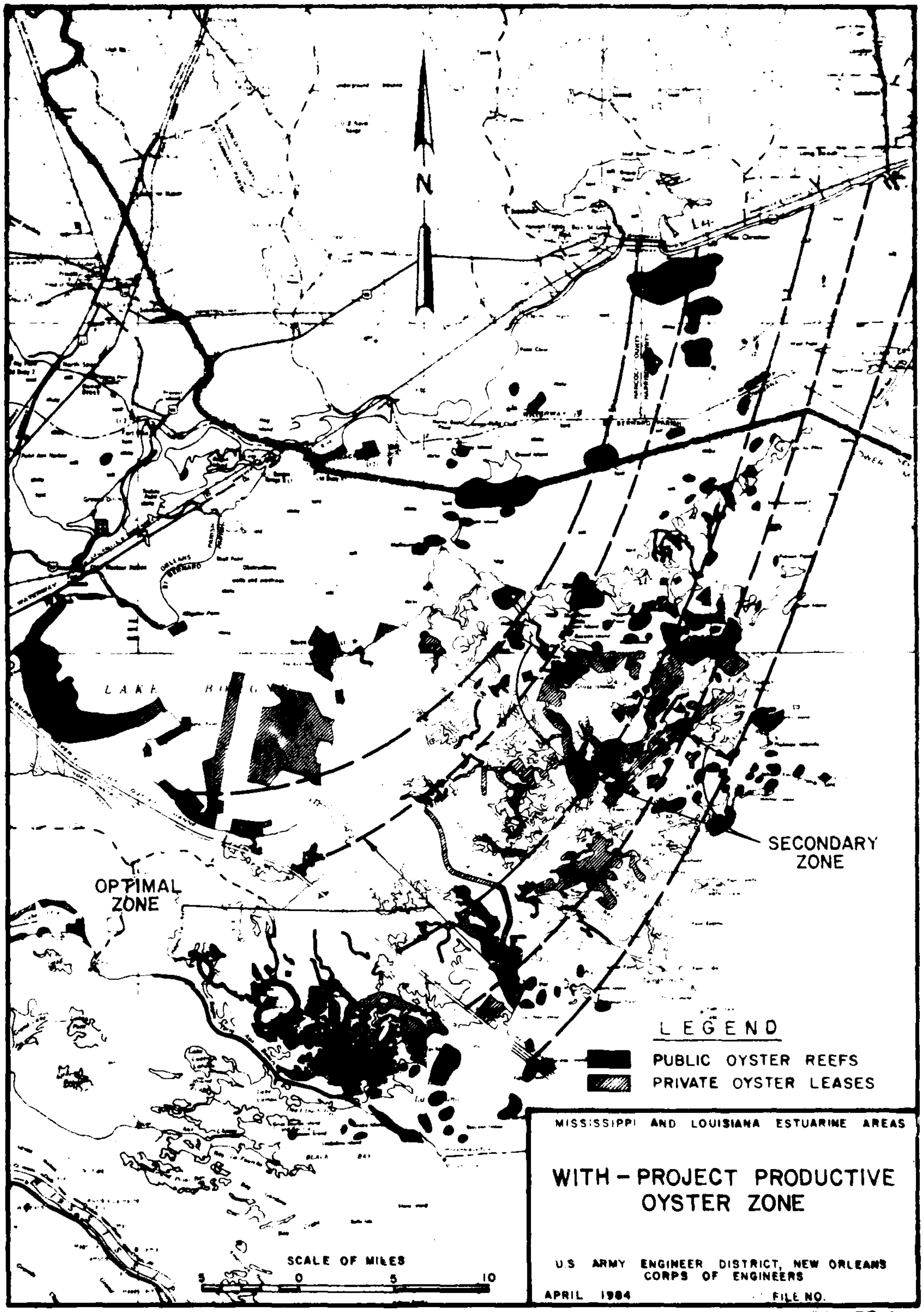
N
SECONDARY ZONE
OPTIMAL ZONE
LEGEND
PUBLIC OYSTER REEFS
PRIVATE OYSTER LEASES
SCALE OF MILES
5 0 5 10
MISSISSIPPI AND LOUISIANA ESTUARINE AREAS
WITH - PROJECT PRODUCTIVE OYSTER ZONE
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
APRIL 1984
FILE NO.

PLATE D-1

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